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The Competitive Status of the U.S. Steel Industry

A Study of the Influences of Technology in Determining International Industrial Competitive Advantage

Prepared by the Steel Panel
Committee on Technology and
International Economic
and Trade Issues

of the Office of the Foreign Secretary
National Academy of Engineering

and the Commission on Engineering and
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National Research Council

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Preface

In August 1976 the Committee on Technology and International Economic and Trade Issues examined a number of technological issues and their relationship to the potential entrepreneurial vitality of the U.S. economy. The committee was concerned with:

- Technology and its effect on trade between the United States and the other countries of the Organization for Economic Cooperation and Development (OECD);
- Relationships between technological innovation and U.S. productivity and competitiveness in world trade; impacts of technology and trade on U.S. levels of employment;
- Effects of technology transfer on the development of the less developed countries (LDCs) and the impact of this transfer on U.S. trade with these nations; and
- Trade and technology exports in relation to U.S. national security.

In its 1978 report, Technology, Trade, and the U.S. Economy,* the committee concluded that the state of the nation's competitive position in world trade is a reflection of the health of the domestic economy. The committee stated that, as a consequence, the improvement of our position in international trade depends primarily upon improvement of the domestic economy. The committee further concluded that one of the major factors affecting the health of our domestic economy is the state of industrial innovation. Considerable evidence was presented during the study to indicate that the innovation process in the United States is not as vigorous as it once was. The committee recommended that further work be undertaken to provide a more detailed examination of the U.S. government policies and practices that may bear on technological innovation.

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The first phase of study based on the original recommendations resulted in a series of published monographs that addressed government policies in the following areas:

- The International Technology Transfer Process.*
- The Impact of Regulation on Industrial Innovation.*
- The Impact of Tax and Financial Regulatory Policies on Industrial Innovation.*
- Antitrust, Uncertainty, and Technological Innovation.*

This report on the steel industry is one of seven industry-specific studies that were conducted as the second phase of work by this committee. Panels were also formed by the committee to address automobiles, electronics, machine tools, pharmaceuticals, civil aviation, and fibers, textiles, and apparel. The objectives of these studies were to (1) identify global shifts of industrial technological capacity on a sector-by-sector basis, (2) relate those shifts in international competitive industrial advantage to technological and other factors, and (3) assess future prospects for further technological change and industrial development.

As a part of the formal studies, each panel developed (1) a brief historical description of the industry, (2) an assessment of the dynamic changes that have been occurring and are anticipated in the next decade, and (3) a series of policy options and scenarios to describe alternative futures for the industry.

The methodology of the studies included a series of panel meetings involving discussions among (1) experts named to the panel, (2) invited experts from outside the panel, and (3) government agency and congressional representatives presenting current governmental views and summaries of current deliberations and oversight efforts.

The drafting work on this report was done by Dr. Joel P. Clark, Massachusetts Institute of Technology. Professor Clark was responsible for providing research and resource assistance as well as producing a series of drafts, based on the panel deliberations, which were reviewed and critiqued by the panel members at each of their three meetings.

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The Competitive Status of the U. S. Steel Industry

Summary

The domestic steel industry, probably more than any other industry in this country, offers a unique opportunity to study the influence of technology and international trade policy alternatives on mature or declining industries. For roughly two decades the steel industry of the United States has been beset by financial problems resulting from a plethora of related factors: severe competition from imported steel, often sold at allegedly "dumping" prices; relatively long depreciation schedules; outdated facilities; de facto price controls; high labor costs; high capital outlays to meet regulatory requirements; poor public relations; and management problems. Moreover, the international trade aspects of the problem appear to be increasing rather than diminishing. The world steel industry has excess capacity and little or no profits while at the same time some developing countries are adding new capacity. These conditions are likely to induce foreign producers to export more steel to the United States, the world's largest and most accessible market.

This summary provides background material and illuminates as succinctly as possible the issues that face policymakers, many of which are similar to those facing other mature or declining industries in this country. It is our purpose to describe policy alternatives and possible consequences, not to recommend actions. A reader seeking details on particular points should refer to the text of this report and to the large number of recent studies of the steel industry referenced within the text.

INDUSTRY CHARACTERISTICS

The domestic steel industry is composed of two main groups, each having two important subdivisions. The main groups are (1) integrated producers, who operate blast furnaces, coke ovens, and steelmaking facilities; and (2) nonintegrated producers, who operate electric furnaces using scrap as the primary raw material. The subdivisions are, by type of product, (1) carbon steel and (2) specialty steel. Carbon steels are iron-based production tonnage commodities containing small amounts of carbon and manganese and sometimes other elements. Specialty steels include alloy and stainless steels and are used in applications where their more expensive properties (e.g., corrosion resistance, high strength-to-weight ratio, etc.) can be justified.

Integrated plants begin with iron ore, coal, and limestone as the primary raw materials for blast furnaces and coke ovens and produce steel from molten iron and scrap. Since only two integrated plants have been built in the United States since 1950, most plants are outdated compared with many of our international competitors.

There are approximately 15 firms operating 36 integrated steel plants in the United States. Together these plants, located primarily in Pennsylvania, Ohio, Indiana, and Illinois, have the capacity to produce annually about 80 million product tons, representing approximately 80 percent of U.S. steelmaking capacity. Each integrated plant consists of up to 29 unit operations with an average capacity of about 3.2 million tons per year (See Figure 1-1 on pages 23-24). Such mills are capital-intensive, having a net plant value of $30,000 to $45,000 per employee.

In 1983 there were more than 50 nonintegrated producers with more than 60 plants in the United States. The nonintegrated producers operate on a much smaller and less capital-intensive scale than the integrated producers because they begin with scrap as the primary raw material.

There are two types of nonintegrated plants: specialty and minimill. Specialty steel plants make alloy and stainless steel and are usually in the 100,000 to 300,000 tons per year production range, with a net plant value of between $15,000 and $25,000 per employee. Total annual capacity is about 5 to 7 million product tons. Specialty and integrated firms are not always distinguishable, however, since some specialty firms are integrated; moreover, alloy and stainless steel is also produced by some large integrated carbon steelmakers.

The nonintegrated producers who make carbon steel products using scrap-based electric furnaces are known as the minimill segment. Minimill operations are similar in level of capital intensity to the specialty producers (about $15,000 to $25,000 per employee). Plant sizes range from about 200,000 to 1 million annual tons capacity. Markets served tend to be local, and product ranges tend to be narrow, concentrating on items such as wire rod, concrete reinforcing bars, and small shapes. Total capacity of the minimill segment is about 15 to 20 million tons per year.

In order to place reasonable limits on the length and depth of the report, our studies concentrated on the integrated producers, since they represent both the largest steel industry segment and also the portion of the industry most affected by international competition. Some attention was also focused upon the domestic nonintegrated steel producers. Despite the fact that these scrap-based segments of the industry are world leaders in technology and costs, the alloy and stainless steel producers have also suffered from international competition. Therefore, some study of this situation contributed importantly to the understanding of the effect of technology and cost structures on international trade issues.

IMPORTANCE OF THE STEEL INDUSTRY

The domestic steel industry is important to the economy and national security of the United States. With average annual sales of almost $60 billion over the period 1978-1983 and gross fixed assets (accounting value of property, plant, and equipment) in excess of $45 billion in 1983, it is one of the largest industries in the nation. The steel industry is also a major source of employment, with approximately 350,000 wage employees in 1983 (down from 456,000 in 1979) and about 150,000 salaried personnel. The total of approximately 500,000 represents about 0.5 percent of the domestic work force.

In addition to the absolute size and direct employment of the industry, it is also important as a basic input to other sectors of the economy. It has been estimated that there are about four times as many indirect jobs in industries dependent upon the steel industry for business in any given year as there are direct jobs in the steel industry. However, it should be noted that some indirect employment will exist at the same level whether steel is produced domestically or imported.

There is no question that steel is critically important to the nation's defense-related industries. Almost every item of military hardware contains steel in some form, and there are no other materials that can provide the required properties at an acceptable cost. Moreover, industries that are vital to the military's need for equipment, transport, and support depend on steel to an important extent.

The national security also depends on a strong industrial economy, and the economic viability of the manufacturing sector is predicated upon a continuous and adequate supply of steel. There is no debate on the issue of whether we should maintain a steel industry capable of providing for a strong national defense. However, there is also no compelling reason why the United

States should adopt policies aimed at maintaining a domestic industry capable of supplying 100 percent of peak demand.

One school of thought argues that it is not necessary from an economic or strategic point of view to maintain a large domestic steel industry. Since imports come from a large number of countries with varied geographical locations and political systems, the probability is small that any political coalition could be formed to deny the United States its requirement for steel. Moreover, it is possible to shift consumption patterns away from consumer uses (e.g., steel for automobiles, containers, home appliances, and construction) toward more essential defense-related requirements in the event of a protracted military emergency. It has been argued that steel shipments to industries serving postponable peacetime consumer needs in 1976 and 1977 were about 45 percent of total shipments, and that adequate supplies of steel should be available to shift to military use in the event of an emergency.

The other line of reasoning is that it is necessary to have a large and strong domestic steel industry capable of supplying a substantial share of domestic consumption in order to be prepared for all conceivable military events and to supply domestic consumers during the periods of peak demand without threats of price gouging and long order delays. There are no official estimates of the minimum domestic capacity needed for national defense, but in a recent report to the National Science Foundation it was estimated that about 90 million tons of steel mill products would be required for direct military and essential support users each year of a protracted nonnuclear war. This estimate implies that about 90 percent of domestic products could be needed in the event of a military emergency and is fundamentally inconsistent with the estimate mentioned in the preceding paragraph.

EFFECTS OF TECHNOLOGY

The primary objectives of this particular study were to relate shifts in industrial technology and costs of production to international competitive advantage and to assess future prospects for further technological change and industrial development. The membership of the steel panel was selected in part with these technological objectives in mind.

There are several important observations that can be drawn from the panel deliberations. Some of the more interesting findings were:

- Leadership in technology does not necessarily assure economic success. For example, the specialty steel segment of the domestic steel industry has long led the world in both process and product development, largely because of the stringent performance demands of the U.S. defense, aerospace, and energy industries. Despite this leadership, the specialty steel division has suffered economic hardship because of imports of the major steel tonnage product, stainless steel (about 16 percent of total sales). This imported product is sold at prices often alleged to be below the full costs of production, or below the exporting nation's own domestic prices. In any case, such sales have seriously eroded domestic profits by reducing the utilization rates of our specialty steel mills.

- The introduction of radical new technologies will probably not be the salvation of the domestic industry over the next 20 years. This view concurs with a recent report by Congress's Office of Technology Assessment (OTA). Instead, there must be continued emphasis on improvements in production costs, product quality, new products, quality of service, and rules governing the international trade of steel products. However, there are radical technologies that could significantly improve the competitive position of the domestic industry if commercial-scale development is realized. Two of these technologies are direct steelmaking and near net shape casting. In direct steelmaking, iron ore and a reductant (e.g., coal and oxygen) are combined in a smelting vessel in which molten steel is produced in essentially a one-step operation. One near net shape-casting technology involves the direct casting of molten steel into strip or sheet with thicknesses in the range of 0.010 to 0.190 inches. It has been estimated that successful development of one of the direct steelmaking processes could result in energy savings of 20 to 35 percent and capital cost reductions of 30 to 50 percent. Continuous casting of steel sheet and strip directly from the melt was estimated to have the potential for total cost savings in the range of $70 to $200 per ton if successful. The probability that any one of these technologies will succeed in the marketplace is not high, however.

- There has been a shift of technological leadership from the United States to Japan over the past 20 or so years. However, the major problem in the integrated mills of the United States is not a lack of technological knowledge, but an inability to generate the capital necessary to deploy known technology to replace or modernize existing old plants and equipment. Domestic firms are not in a position to show the levels of profitability necessary to raise funds in the capital markets for such investments in their steelmaking operations. Moreover, it must be recognized that U.S. producers have not had the experience of some of their competitors, particularly the Japanese, in deploying and redeploying the most modern technology, and that some time may be required to catch up in that respect. Nevertheless, modern integrated mills based upon imported technology in some countries (e.g., South Korea) are producing steel at lower costs than the most efficient Japanese mills because of lower wage rates. (See Chapter 3 for a discussion of comparative labor costs.)

- Sometimes technological leadership leads to economic success, as in the case of the minimill division. But that is not the whole story. The minimill group also enjoys low scrap and power costs and high labor productivity compared with their international competitors. Moreover, they tend to serve local markets in a manner that is difficult for foreign suppliers to match.

PRODUCTION COSTS

A number of reports on the steel industry have included estimates of international production costs. These are difficult to compare because methodologies and assumptions differ and time frames vary. However, even given the difficulties of comparison, it is possible to draw some general conclusions regarding relative production costs.

In 1978 the differential between the average total costs in the United States and Japan was between 10 and 15 percent (depending upon the exchange rate) in favor of the Japanese. However, the radical shifts in exchange rates since then have led to a deterioration of the competitive position of U.S. producers. By 1981 the integrated carbon steel firms of the United States were among the highest-cost producers in the world: higher than those in most of the EEC countries and Japan. As the dollar continued to strengthen in 1982-1983, the U.S. industry became even less competitive in the world market.

Costs in the international market do not have as much significance as landed costs in the U.S. market because U.S. producers export only a few percent of their total production. Moreover, it is the distribution of costs across producers, rather than average costs, that provides the greatest insight into the competitiveness of U.S. firms. Although more recent data are not available, a survey conducted by Arthur D. Little indicated that in 1979 between 4 and 27 percent (depending upon the product type) of domestic plants had costs at least 25 percent above the average.

In 1978 the average carbon steel product imported from Japan--taking into account the cost of freight, handling, insurance, working capital, and import duty--would have had a total landed cost of about $385 per net ton on the West Coast and about $395 per net ton in the Great Lakes area. Using almost any of the total cost estimates for U.S. producers reported in Chapter 3, and adjusting the transportation cost results in the same conclusion: the average current practice steel plant, particularly those in interior regions of the United States, would have been able to meet the full-cost price of Japanese producers in interior regions of the United States. However, those domestic plants with costs significantly above the average (say 15 percent) or in coastal regions would have difficulty covering a substantial part of their fixed costs at the Japanese full-cost price. The data suggest that on the order of 25-30 percent of the domestic capacity that existed in 1980 (total raw steel capacity was about 154 million annual net tons in 1980) will be retired in the future because the plant can not meet competitive import prices. The recession of 1981-1983 and the strength of the dollar have already led to a reduction, as of early 1984, of about 25 million tons of raw steel capacity. However, because some firms have not yet written high-cost plants off of their books, additional plant closings are likely in the future.

MARKETS FOR STEEL PRODUCTS

There are two important characteristics of the demand for steel products in mature economies such as those of the United States, western Europe, and Japan. First, the demand for steel grows at a significantly slower rate than that of the overall economy. In the United States the long-term growth rate varies depending on the time period used for the calculation, but in the past 20 years this rate has been roughly 1.0 percent annually. Over the past 10 years, the growth rate of domestic steel consumption has been slightly negative. Although growth rates in western Europe and Japan were significantly higher than those of the United States during the rebuilding years following the Second World War, in the past 10 years steel consumption trends in these two regions have been similar to those in the United States.

Second, although the overall trend is for slow growth, there are significant cyclic fluctuations throughout this trend. This should not be surprising when one considers that approximately 75 percent of total steel consumption in the United States is the result of public and private (including local) capital investment.

The future outlook for total steel consumption in the United States is as uncertain as the outlook for the aggregate economy because the consumption of steel is so closely correlated with the level of industrial production. There is reason to believe that a surge in expenditures for capital investment projects could precipitate a peak in steel demand at some point in the future, but it appears that the trend is for stagnant steel demand in developed countries. Although steel consumption in developing countries should grow at about 5 percent annually, total world steel consumption is expected to exhibit minimal growth at best for the remainder of the century.

INTERNATIONAL PRODUCTION TRENDS AND THE SUPPLY-DEMAND BALANCE

Estimates of present and future raw steel production capacity in geographical and political sectors of the world are presented in Chapter 5. These estimates, when compared with the projections of world steel consumption, show two major effects. First, it is probable that there will be an overcapacity problem in world markets through at least 1985 and probably through 1990. After 1990 the supply-demand balance may become tighter, but in the event of accelerating demand, it is expected that capacity will be expanded in developing countries at a relatively fast rate. Second, the developing and socialist countries will account for the large majority of capacity expansion in the future. This will pose a problem for the United States because increased pressure will be placed on the U.S. import markets, and the potential for overproduction will lead to lower prices for steel products on the world market.

IMPORTS OF STEEL PRODUCTS

Imports have been a major problem facing U.S. steel producers since the mid-1960s, increasing by about fourfold from 1963 to 1982. In the past few years, imports have captured on the order of 20 percent of the domestic market.

It is generally agreed that foreign producers have used the price mechanism to penetrate the U.S. steel market. They have, in most cases, undercut the prices of comparable quality domestic steel (except during 1974), whereas the U.S. producers have been unwilling or unable to meet these lower prices.

There are basically three hypotheses for explaining lower foreign prices. The first is that foreign producers enjoy an actual cost advantage over U.S. producers. The second is that no cost advantage exists, but unfair or illegal trade practices lead to lower import prices. The third is that foreign producers practice supply and demand pricing in a depressed market while U.S. producers have tried to maintain cost-plus pricing. Since supply-demand pricing in a depressed steel market will usually lead to prices below full costs of production, its status under U.S. trade law is not certain, although such pricing is not necessarily illegal under the General Agreement on Tariffs and Trade (GATT).

This report discusses these hypotheses as well as the role that other factors--including labor negotiations, GATT, and the Trigger Price Mechanism--have played in the import market.

PROBLEMS OF THE DOMESTIC INDUSTRY

A major problem facing U.S. firms is one of overcapacity in the world steel market. A primary reason for the overcapacity is that the world steel market does not work efficiently according to free market criteria. It does not work efficiently because of factors such as (1) government investment in steel plants, particularly in developing countries; (2) subsidies to steel plants that increase output and reduce the probability of plant closure; and (3) protectionism in domestic markets for steel products.

The overcapacity has resulted in a situation where markets for steel products have been depressed roughly three out of every four years for the past two decades, with little change likely in the future. Depressed world markets have contributed to a poor record of profitability for domestic producers in recent years. Other factors that led to the poor financial performance include (1) relatively high costs of some domestic plants due to old production facilities, relatively high labor costs (compared with the average costs in the manufacturing sector of the United States or with the labor costs in the steel industries of competing countries), costs of compliance with government regulations, and, until recently, relatively long capital depreciation schedules compared with most other countries; and (2) relatively low revenues due to real or de facto price controls and the loss of market share due to the reluctance of domestic producers to engage in supply-demand pricing.

The recession of 1982 contributed to the major structural changes in the domestic steel industry: (1) decreased capacity by retiring older inefficient plant and equipment, (2) a new labor agreement with wage and work practice concessions by the United Steelworkers of America, and (3) a change in pricing policy from cost-plus (i.e., production cost plus a profit margin) to supply-demand pricing based on international market conditions. The major implication of the first two factors is that the domestic industry will be more cost-efficient and better able to profit from a recovery when it occurs. The results of the third change include an increased willingness by domestic producers to compete with imports on the basis of price but decreased revenues from the lower price realizations.

POLICY ALTERNATIVES

It is likely that the domestic steel industry will be forced to undergo further contractions to remain competitive in the international arena. Many U.S. plants have an uneven mix of facilities, combining modern equipment with older, inefficient operations. If domestic firms are to emerge from the current crisis in a healthy state, the most efficient operations must be saved, clearly inefficient operations should be closed, and mixed facilities must be encouraged to modernize and restructure themselves to respond to the intense international competition.

Such a restructuring process will be difficult and expensive, and more jobs will necessarily be lost. In addition to the costs of modernization, "shutdown" costs--severance benefits, payments to steelworkers for supplemental unemployment benefits and unemployment compensation, and the extended costs of continuing pension contributions resulting from termination or retirement of employees--will be high.

The areas of major policy alternatives available to government and industry (including labor and management) decision makers include trade, environment, antitrust, and technology. Of these, trade is currently the most important. Each is summarized below.

Trade Policy

Continuation of Current Policies

Steel import policies under the Reagan administration have taken the form of quantitative restrictions. In 1982 the European Economic Commission agreed to limit their exports of carbon steel products through December 1985 within limits set as maximum percentages of projected U.S. apparent consumption.

More recently, the President rejected an International Trade Commission proposal to place quotas on finished steel products from all sources, in favor of negotiating voluntary quotas on a bilateral basis with our trading partners.

Antidumping Suits/Countervailing Duties

Under the antidumping alternative domestic firms have the right to bring suit against foreign suppliers in the courts. In such an instance it is up to the U.S. Department of Commerce to determine if imported steel is being sold in the United States either (1) at a price (mill net-return basis) lower than the home market price, or (2) in the absence of price discrimination, at a price less than full cost for a substantial period of time.

It is also possible for domestic steel producers to file suits against exporting firms if they are receiving subsidies from domestic governments. In such a case, if the U.S. Department of

Commerce issues preliminary findings that steel imported from foreign countries has benefited from government subsidies, the importers are required to post cash deposits equal to the estimated subsidy to be put in escrow and paid to the domestic government if (1) the final determination is affirmative and (2) the U.S. International Trade Commission finds material injury.

The major benefits of following either the countervailing duty or antidumping alternative is that the U.S. industry would see clearly the maximum extent of protection afforded by U.S. fair trading laws. Firms that are found guilty of violation of the U.S. trade laws would pay the penalties and the U.S. treasury would receive the revenues. Finally, letting the U.S. legal process run its course (by not reaching a political settlement) would test whether the threat of a trade war is real. If the United States obligates itself to submit to GATT review any positive findings of subsidization, dumping, or injury, the possibility of retaliation may be reduced.

The negative side of these alternatives is that there is no assurance that the imposition of unfair trade duties on particular countries or geographical regions would prevent other countries from expanding their exports. For instance, import duties on European steel will not necessarily prevent developing countries, or even Japan, from attempting to increase their share of the U.S. market. Moreover, the task of determining the amount of subsidy, particularly for developing countries, will be ambiguous. For instance, the emerging nations' steel facilities will clearly be forced to accept a number of government-imposed inefficiencies. There is a question as to whether our import laws require that these inefficiencies be added to the cost of production in determining fair market value. In addition, there will be difficulty in separating operating costs for current production from the costs of continuing construction and the plant's initial shakedown. Moreover, exchange rates and other prices may not reflect economic forces due to government intervention. The question is whether our trade policy administrators can adjust for these distortions.

The above discussion suggests that simplistic approaches to "fair" pricing of imports may be unworkable in the future, partly because there is no general agreement about what fair pricing means. Determinations of subsidies, product costs, and market value will become increasingly difficult as governments assume more and more of the capital burden of the world steel industry. It is not clear that our countervailing and antidumping procedures can cope with these complexities.

Finally, it should be noted that major trade suits have not been allowed to run their course though our administrative-legal procedures because of the time required and the potential for precipitating a trade war. Exporters and importers of steel must wait nine months or more for the U.S. authorities (and the courts) to affirm the legality of their prices. Moreover, there have been reports that the Europeans are considering retaliating against the U.S. actions on steel products in the areas of chemical, textile, and agricultural products. Thus, in the past, major dumping or countervailing duty suits have been settled through a rapid political adjudication among the complaining industry, the U.S. government, and its trading partners.

Tariffs

One alternative to letting the dumping and countervailing duty suits run their courses is a tariff. The advantages of a tariff are simplicity of administration and enforcement, generation of revenues for the U.S. Department of the Treasury, and its consistency with flexible pricing. Disadvantages are possible inconsistencies with GATT and the likelihood that our trading partners would impose similar duties on products that we export in abundance.

A variation on a straight tariff is one that is staged over time. It has been proposed that a tariff could be devised such that it is initially high enough to protect the domestic industry at or near its current size but would shrink over time to a final level large enough to assure domestic capacity sufficient for national defense requirements. Such a system was previously implemented for the domestic magnesium industry.

Trigger Price Mechanism

The relative merits of a revised trigger price mechanism are similar to those of a tariff. However, the consumer would pay higher prices and the revenues that accrue from such a system would go to foreign producers rather than to the U.S. Department of the Treasury. Thus, even though it might be theoretically possible to devise a new trigger price system with similar features to the transitional tariff previously described, the bad experience (of most of the interest groups involved) with the two previous attempts at reference prices mitigates against a renewed effort.

Quantitative Limitations

Although quotas have been administered in the past, such a system would be much more complex to enforce now than 12 years ago with the Voluntary Restraint Agreements (VRAs) because of the recent proliferation of steel exporters. A major disadvantage of such a trade restriction is that it eliminates entirely any foreign price competition (although, to some extent, tariffs, trigger prices, and other methods also eliminate foreign price competition) and therefore weakens the constraint on domestic wage settlements. Other problems with quantitative restrictions include (1) doubt about the admissibility of quotas under the Tokyo Agreement, (2) the likelihood of initial confusion and hedge buying before a new system could be put into effect, and (3) an undesirable forced cartelization of steel exporters to the United States that would accompany such a mechanism.

On the positive side, limiting the quantity of imports is the most direct way of assuring the domestic industry a specific market share. Moreover, such restrictions are not susceptible to fluctuations in exchange rates and supply-demand balances.

Environmental Policy

The economic effects of environmental controls (for air and water pollutants) on the U.S. steel industry was the subject of a recent report by Arthur D. Little, Inc. (ADL) for the American Iron and Steel Institute. Although it was pointed out that the accuracy of the estimates vary between ±15 percent and ±35 percent, it appears that environmental controls will not pose a major problem for the domestic industry if only current environmental requirements are enforced.

Antitrust

One alternative open to the U.S. government to assist the industry with modernization and restructuring is a consistent, flexible, and more liberalized antitrust policy. Some of the elements of such a policy might include permitting and encouraging:

1. mergers and acquisitions, to permit the creation of more efficient steel companies, by combining and matching facilities of existing operations;
2. joint ventures, to reduce the capital costs to a single firm of facilities such as blast furnaces or large finishing mills, where economies of scale and utilization rates are important;
3. jointly sponsored research and development, to allow the industry to share the costs associated with high risk/return projects.

It is quite unlikely, in the absence of more restrictive import protection than currently exists, that a more liberalized antitrust policy would affect domestic steel consumers in an adverse manner. The large number of competitors in the domestic steel market--minimills and integrated producers in the United States and producers from abroad--ensure that competition will be intense in the future under almost any scenario.

Technology Policy

The government has recently invested rather heavily in fairly basic research in materials in various university, government, and some industrial laboratories. This practice is desirable and might have some effect in the future on steel processes and products, as well as training needed personnel.

The government has also tended to encourage cooperative research between steel companies on large, costly projects by not refusing to permit such projects because of possible antitrust aspects. This policy should be continued.

In general, the industry prefers to fund its own research rather than to accept government funding or sharing. Although exceptional cases should be weighed carefully, this policy seems appropriate.

CONCLUDING STATEMENTS

There is no disagreement that the U.S. steel industry is in trouble. The key question is whether the government should take any steps to aid the revitalization of the industry. The answer to this complex question differs according to varying beliefs about the national security implications of the decline, the causes of the decline, the effects of the decline on the economy, and the effectiveness of any chosen government action. However, it is clear that none of the commonly recommended measures--including no action--will make all the parties involved better off; thus there appears to be an inherent conflict among objectives. How this conflict is resolved will likely be determined by political compromise.

If the U.S. government does not provide some relief, the workers employed in the steel industry--at least in the older, less efficient plants--will suffer, along with the regions where such plants are located. It is possible (and perhaps more cost-effective, although a definitive analysis of the net economic costs of government policy alternatives has never been undertaken) to compensate these employees and regions by actions other than support for the steel industry, but so far there does not appear to be any comprehensive program to do so. The closing down of a big steel plant is likely to have a devastating effect on the economy and quality of life in the local community. Substantial declines will occur in the value of real estate around the plant, in the tax revenues to support schools, and in the economic activity of the local community. Who should be responsible for the loss of homes of the workers who must move into other occupations in other regions? Who should be responsible for maintaining the schools and for the health of the local economy? The shareholders of the steel companies may also suffer capital losses.

If the U.S. steel industry shrinks as a result of the lack of appropriate action from the government, some domestic consumers of steel may also suffer. These are the users to whom a reliable domestic supply is paramount, and the costs associated with the greater dependence on imports are related to the uncertainty of supply. For instance, during those periods when the world industry is operating at a high rate of capacity utilization, U.S. consumers who are dependent on foreign sources of supply could expect not only higher prices but relatively longer order delays. Therefore, it is likely that steel consumers would find it necessary to carry larger inventories and/or to utilize long-term contracts, with the associated costs. However, the infrequency of supply shortages and the cost of maintaining adequate capacity for such shortages may mitigate against direct government action.

Steel users in general are likely to lose if the government provides direct aid to the steel industry because most of the support measures--especially import restrictions--are likely to increase the price of both domestic and imported steel. There are also formidable practical and political difficulties associated with enforcing import restrictions, as we have discovered in recent years. Moreover, our problems with imports are likely to be more severe in the future. Even if we are able to negotiate successfully the narrow straits between successfully limiting European and Japanese imports and precipitating a trade war, there is an entirely new series of exporters waiting on the horizon (e.g., Korea, Trinidad, and Brazil) as a result of the projected government involvement in the world industry.

From the point of view of the economy as a whole, if the U.S. steel industry does not have a competitive advantage, supporting the industry may lead to a misallocation of real resources and a consequent reduction in welfare. On the other hand, if the industry's competitive position is weak not because of competitive disadvantage but because of other distortions, the overall welfare can be increased by removing these distortions. One such distortion may be excessive regulation. However, the controversy over government regulation has recently subsided substantially. As discussed in Chapter 8, Environmental Protection Agency (EPA) regulations are expected to have minimal effect on the productive capacity of the industry; the new Economic Recovery Tax Act, as it existed in 1981, effectively removed tax policy as an impediment to investment, although recent changes to that legislation (e.g., modifications to the Safe Harbor Leasing provisions) will be detrimental to the steel industry.

The dominant issue is whether subsidization of foreign producers by their governments is such a distortion. On the one hand, if actions by foreign governments result in domestic consumers receiving lower-priced steel, this is almost like a free transfer of resources from abroad to domestic users. Unless there is some strong apprehension that foreign producers will collude and raise prices later on--which appears unlikely from the point of view of efficiency--there is no reason to continue to allocate resources to the domestic industry. On the other hand, if subsidization by foreign governments results in increased imports to the U.S. market, as it almost surely will, this may be considered to be a policy of exporting unemployment and all the associated social costs.

Introduction

The steel industry of the United States--the world's strongest in terms of production capacity, technological efficiency, and profitability from the early 1900s until about 1960--reached the mature stage of its development in the decade following World War II. America no longer enjoys the halcyon days when it owned the most modern and technically efficient plants. Production capacity is shrinking, and the United States has been a net importer of steel since 1959.

In the past two decades the U.S. steel industry has periodically experienced a series of crises characterized by stagnant or declining production, loss of home market share, declining employment, relatively low price-cost ratio, and poor earnings. Each of these crises has led to pressures on the federal government to take action to improve the competitive position of the industry. However, since the political pressure groups and the government have generally sought immediate short-term relief for each crisis, less attention has been placed on longer-term solutions that would allow the industry to make the adjustments necessary to compete in changing international markets.[1]

In addition to the turbulence of the past 25 years, the domestic steel industry has experienced perhaps more flux in the period between 1980 and 1984 than in any other similar period in its history. A list of events that have had an important impact on the steel industry since 1980 include the following:

- record high levels of steel imports;
- payments of fines for "dumping" steel products in the United States by foreign firms;
- findings by the U.S. Department of Commerce of subsidization of foreign steel companies by host governments;
- findings by the U.S. International Trade Commission of injury to domestic firms resulting from subsidies by foreign governments;

- agreement with the EEC on limiting steel exports to the United States;
- record low operating rates;
- acceptance of a wage reduction and changes in work practices by the United Steelworkers of America;
- announcements of discussions since abandoned by the U.S. Steel Corporation and the British Steel Corporation whereby U.S. Steel would import semifinished steel to its Fairless works and close the primary end of the plant;
- announcement of a merger between Jones and Laughlin (LTV) and Republic Steel;
- large layoffs of white- and blue-collar workers by domestic firms;
- plant closings resulting in significant reductions in domestic steelmaking capacity.

The reasons for the declining competitive position of the United States steel industry have been the subject of a number of studies and reports published during the past decade.[2] Although there are differences of opinion concerning the causes and solutions of its problems, all of these documents agree that the U.S. steel industry--as well as the steel industries of many other geographical regions of the world--is currently in dire financial straits. The integrated segment of the domestic steel industry has suffered markedly lower levels of profitability than most other manufacturing industries and has experienced considerable difficulty in financing modernization and capacity replacement programs with internally generated funds.

Some of the reasons that have been given for the historically poor financial performance of U.S. firms include the following:

1. Reduced revenues due to:
    loss of share of the domestic market;
    stagnant demand for steel products in the markets of the developed world.
2. Increased costs due to:
    government controls and regulations, particularly those related to the environment and health;
    outdated and inefficient plant and equipment, partly as a result of poor investment decisions by management;
    taxation policies that fail to provide for adequate capital recovery;
    high labor costs due to demands for compensation (wages and fringe benefits) and work rule practices by the United Steelworkers of America (USW);
    relatively high materials costs due to shifts in transportation rates and ownership patterns of resources.

The primary objectives of this report were to relate shifts in industrial technology and costs of production to international competitive advantage and to assess future prospects for technological change and industrial development. Estimates of global trends in steel trade, production, and consumption, and the effects of alternative government policies on the domestic steel industry are also provided as background for the report.

The report is organized as follows: Chapter 1 contains a brief overview of the steel industry, including the structure of the industry, the technology of steel production, and the importance of the industry to the aggregate economy and to the national security of the United States. Chapters 2 and 3 assess the technology and the costs of production of the domestic industry in relation to its major competitors. Chapter 4 reviews historical trends in the production of steel and includes projections for the future. Chapter 5 provides an assessment of the markets for steel products, both in the United States and in international markets. Chapter 6 analyzes the role and share of imports in the United States market. Chapter 7 discusses the problems that currently confront the industry. The final chapter includes a discussion of policy alternatives, the effects of these alternatives on the industry, and the attendant implications of each.

NOTES

1. A history of government policies affecting the domestic steel industry from the World War II years through early 1982 has recently been completed and is available in Trozzo (1982).

2. Recent studies and reports include the following (Complete reference material is contained in the References.):

Trozzo (1982).
American Iron and Steel Institute (1980).
U.S. Office of Technology Assessment (1980).
U.S. General Accounting Office (1981).
Tripartite Advisory Committee (1980).
Robbins (1979).
Hall (1980).
Arthur D. Little, Inc. (1981).
Crandall (1981).
Mueller and Kawahito (1978).
American Iron and Steel Institute (August 1981).
Szekely (1979).
American Iron and Steel Institute (June 1981).
Old et al. (1981).
Barnett and Schorsch (1983).
Hogan (1983).

1
Industry Background

STEELMAKING OPERATIONS

Steel mills fall into two main groups, each having two important subdivisions. The two main groups are integrated producers operating blast furnaces, coke ovens, and steelmaking facilities; and nonintegrated producers operating electric furnaces and using scrap as the primary raw material. The subdivisions by type of product are carbon steel and specialty steel. Carbon steels are iron-based tonnage commodities containing small amounts of carbon and manganese and sometimes other elements. Specialty steels include alloy and stainless steels and are used in applications where their more expensive properties (e.g., corrosion resistance, high strength-to-weight ratio, etc.) can be justified.

There are approximately 15 firms operating 36 integrated steel plants in the United States. Together these plants, located primarily in Pennsylvania, Ohio, Indiana, and Illinois, represent about 80 percent of domestic steelmaking capacity. Each integrated plant consists of up to 29 unit operations (discussed subsequently in this chapter) with an average capacity of about 3.2 million tons per year. Such mills are capital-intensive, having a net plant value of $30,000 to $45,000 per employee.

In 1981 there were more than 50 nonintegrated producers operating more than 60 plants in the United States, with a total production capacity of about 20 to 25 million net tons annually. (Data are provided for 1981 rather than 1982 or 1983 because 1981 was considered a more typical year for the steel industry.) The nonintegrated producers operate on a much smaller and less capital-intensive scale (since they begin with scrap as the primary raw material) than do the integrated producers. Specialty steel plants are usually in the 100,000 to 300,000 tons per year production range, and the net plant value is about $15,000 to $25,000 per employee. Recent trends in the output of grades of steel products are shown in Table 1-1.

TABLE 1-1 U.S. Raw Steel Output by Grade (thousands of net tons)

Year	Carbon	Alloy	Stainless	Total
1965	116,651 (88.8%)	13,318 (10.1%)	1,493 (1.1%)	131,462
1970	117,411 (89.3%)	12,824 (9.7%)	1,279 (1.0%)	131,514
1975	100,360 (86.0%)	15,171 (13.0%)	1,111 (1.0%)	116,642
1976	112,008 (87.5%)	14,308 (11.2%)	1,684 (1.3%)	128,000
1977	108,130 (86.3%)	15,341 (12.2%)	1,862 (1.5%)	125,333
1978	116,916 (85.3%)	18,161 (13.3%)	1,954 (1.4%)	137,031
1979	116,226 (85.3%)	18,008 (13.2%)	2,107 (1.5%)	136,341
1980	94,689 (84.7%)	15,445 (13.8%)	1,701 (1.5%)	111,835
1981	101,462 (84.0%)	17,623 (14.6%)	1,743 (1.4%)	120,828
1982	64,143 (86.0%)	9,198 (12.3%)	1,235 (1.7%)	74,577
1983	72,463 (86.9%)	9,163 (11.0%)	1,752 (2.1%)	83,378

SOURCE: American Iron and Steel Institute, *Annual Statistical Report*, years given.

The nonintegrated producers, making carbon steel products using scrap-based electric furnaces, are known as the minimill segment. Minimill operations are similar in level of capital intensity to the specialty producers (about $15,000 to $25,000 per employee) and plant size, which average about 300,000 to 330,000 annual tons capacity, with the largest around 1,500,000 tons per year. Markets served tend to be local and product ranges narrow, concentrating on items such as concrete reinforcing bars, fence posts, and smaller shapes. Total capacity of the minimill segment is about 15 to 20 million tons per year.

It should be noted that the producers classified as integrated also maintain scrap-based mills. In 1982, of the integrated producers' collective 47 mills, 11 were scrap-based and accounted for about 9.4 million tons of annual capacity.

In 1981 the total capacity to produce raw steel was about 154 million net tons, with the top five producers accounting for approximately 94.4 million tons or 58 percent of the total. The top 10 producers comprised approximately 76 percent of this total.

From the preceding discussion it should be apparent that the various segments of the steel industry differ substantially in character. They also differ in the status of their technology and international competitiveness. The panel chose in this report to focus largely on the integrated carbon steel producers for the following reasons:

1. The integrated carbon steel producers face considerable international competition, both from imports and technology, and they dwarf the other segments in output and sales.

2. The minimill producers face little international competition as they are able to serve local markets effectively, utilizing plants that are both technology- and labor-efficient.

Although the primary focus is on integrated producers, some attention must be directed toward the relatively small specialty steel producers because they also face stiff international competition, despite maintaining technological leadership or equality.

In the following section of this chapter we briefly review the technology of carbon steel production by the integrated route.

TECHNOLOGY OF STEEL PRODUCTION

The complete steel production sequence of a typical integrated operation is composed of six main steps: coke production, iron ore agglomeration, ironmaking, steelmaking, casting, and finishing. A schematic drawing shown in Figure 1-1 illustrates the sequence of as many as 29 unit operations[1] that occur in typical integrated operations.

In general, the integrated steel production process starts with coal and iron ore as basic raw materials. These materials are then converted into coke and iron ore pellets, or sinter, in coke ovens and beneficiating plants, respectively. Coke and beneficiated iron ore are charged with limestone in the blast furnace and smelted to form pig iron and slag. Molten pig iron and/or steel scrap is refined in steelmaking furnaces to form raw steel. Finally, finished steel products are produced through casting and mechanical working operations. Each process is outlined briefly in the following sections. Appendix B provides details about the requirements of each of the major unit operations for capital, labor, and materials, and estimates of typical production costs.

Coke Production

Coking is the process for carbonizing coal. In this operation, coking-quality coal is heated in an oxygen-lean atmosphere until most of the volatile matter is removed. This distillation process yields a coherent cellular residue high in fixed carbon (83 to 90 percent), known as coke. It is subsequently utilized in the iron blast furnace and fulfills three major roles:

1. producing and regenerating gases for the reduction of iron oxide;
2. providing an open, permeable bed through which slag and metal pass down into the hearth and hot reducing gases pass up into the stack; and
3. as a fuel, providing heat for meeting the endothermic requirements of chemical reactions and melting the blast furnace charge to produce molten metal and slag.

The coking process yields valuable by-products. One of these is coke oven gas, some of which generally is recirculated to underfire the coke ovens, while the rest is used as a fuel in other parts of the steel plant or sold to other commercial users. Other by-products include ammonia, tar, and light oil. These undergo further processing and are sold. Coke breeze (undersized coke) produced is used primarily in the sintering process.

In 1981, 54 million tons of coking coal were consumed by the domestic steel industry. This corresponds to the production of 38 million tons of coke for steelmaking.

The technology of coking is well established and no major innovations are foreseen. One minor change that may prevail is the shift from wet quenching of the coke to dry quenching. Such a change will decrease the water demand for coking operations. If efficient heat recovery systems are devised, it should also improve the energy efficiency and yield.

Ore Agglomeration

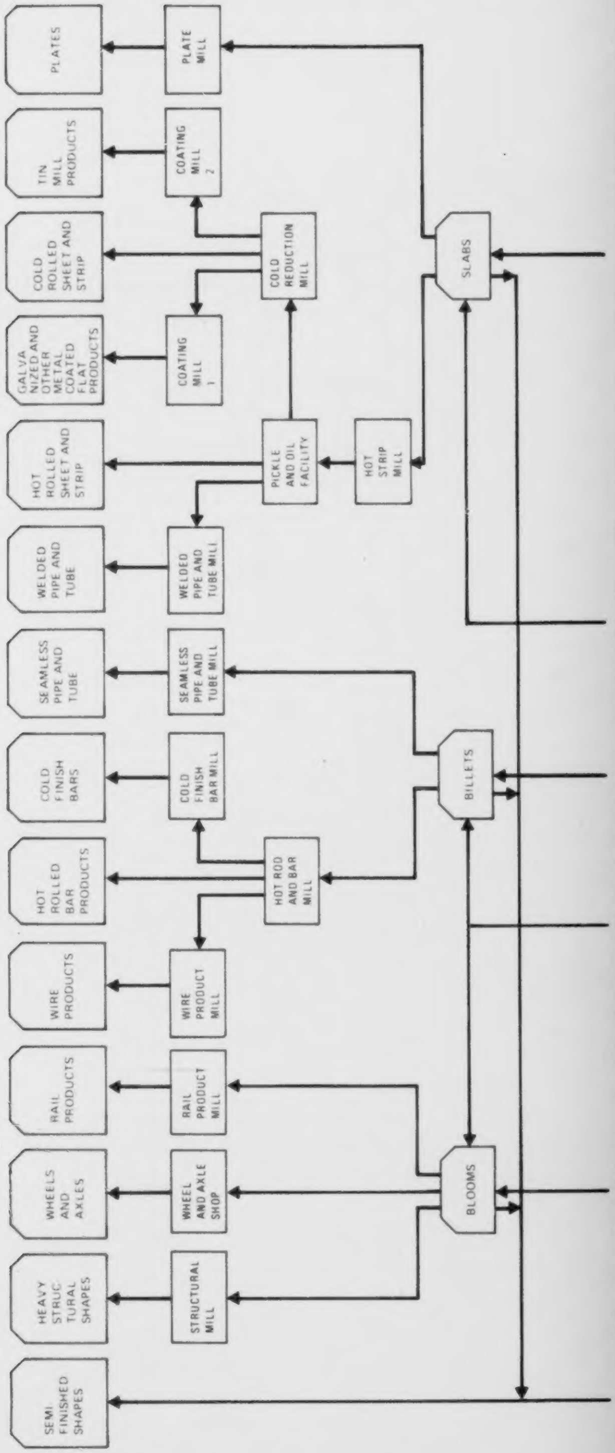
Pelletizing

Pelletizing is an agglomeration process in which loose, finely ground iron ore is transformed into rigid, round pellets. The process involves forming "green" or wet pellets, then firing these at a temperature sufficiently high to cause them to fuse. Iron ore is pelletized to improve the efficiency of blast furnace operation. Forming the iron ore into pellets ensures that reducing gases will pass easily and uniformly through the furnace.

In 1981 domestic pellet production was estimated to be 68.3 million tons. Additionally, 15 million tons of pellets were imported. Pellets represent about 70 percent of the domestic agglomerated ore production. Pelletizing is a relatively new technology, and its use has spread rapidly in the past 30 years. However, significant improvements in pelletizing technology are not foreseen.

Sintering

Sintering is an agglomeration process in which loose iron ore is transformed into rough, porous, coherent "lumps." Coarse iron ore is mixed with a small amount of finely powdered solid fuel (e.g., coal fines, coke breeze). Slagging materials such as limestone may also be added. The mixture is deposited onto a metal grate where it is ignited. As it burns, heat causes the ore and slag to fuse into a porous, solid "sheet." This fused mixture is broken


SLABS
BILLETS
BLOOMS
PLATE MILL
PLATES
COATING MILL 2
TIN MILL PRODUCTS
COLD REDUCTION MILL
COLD ROLLED SHEET AND STRIP
COATING MILL 1
GALVANIZED AND OTHER METAL COATED FLAT PRODUCTS
HOT STRIP MILL
PICKLE AND OIL FACILITY
HOT ROLLED SHEET AND STRIP
WELDED PIPE AND TUBE MILL
WELDED PIPE AND TUBE
SEAMLESS PIPE AND TUBE MILL
SEAMLESS PIPE AND TUBE
COLD FINISH BAR MILL
COLD FINISH BARS
HOT ROD AND BAR MILL
HOT ROLLED BAR PRODUCTS
WIRE PRODUCT MILL
WIRE PRODUCTS
RAIL PRODUCT MILL
RAIL PRODUCTS
WHEEL AND AXLE SHOP
WHEELS AND AXLES
STRUCTURAL MILL
HEAVY STRUCTURAL SHAPES
SEMI FINISHED SHAPES

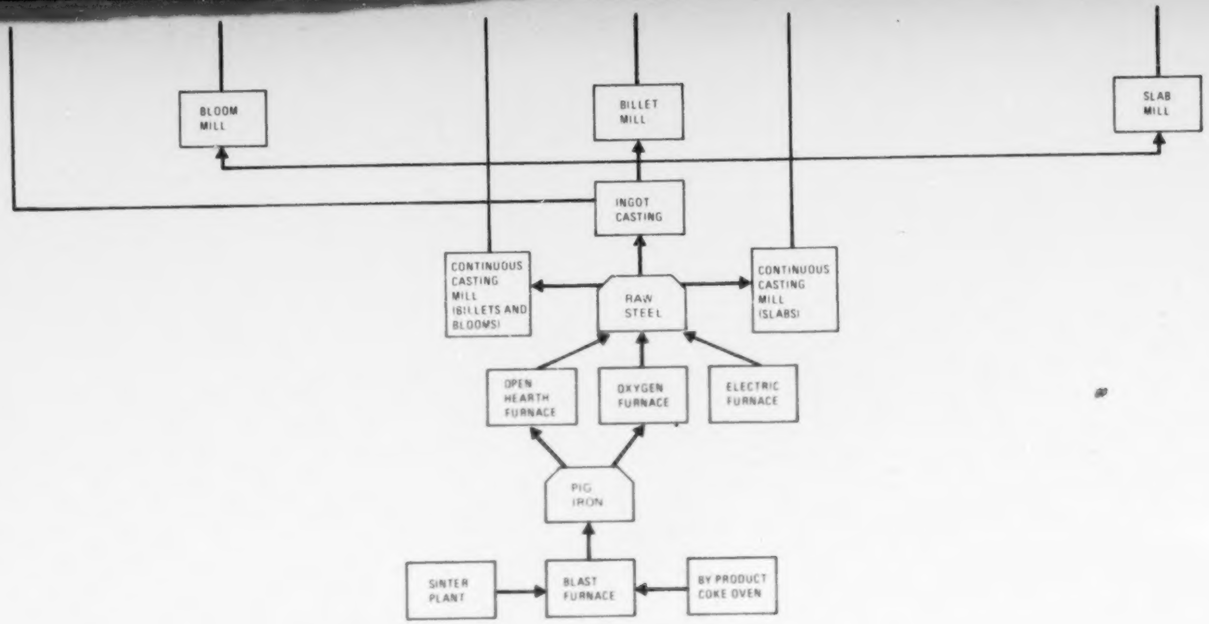


FIGURE 1-1 Unit Operations in the Steelmaking Sequence.

SOURCE: Clark et al. (1982).

into lumps of a convenient size for charging into blast furnaces or direct reduced iron (DRI) furnaces.

Iron ore is sintered for the same reasons that it is pelletized--to ensure good air flow through a packed bed.

In 1981, 27.4 million tons of sinter were produced domestically,[2] primarily in large, integrated steelmaking facilities. Generally, sinter is not sold on the market. Rather, it is produced internally where its production consumes by-product materials such as coal and coke powders and blast furnace fines.

Ironmaking--The Blast Furnace

The blast furnace is the most prevalent unit operation for reducing iron ore to metallic iron. The iron blast-furnace process consists of charging prepared iron ore (in the form of direct ore, pellets, or sinter) with coke and limestone (and sometimes a small quantity of steel scrap) into the top of a countercurrent shaft furnace. A continuous blast of preheated air, sometimes accompanied by fuel oil, powdered coal, or natural gas, is introduced into the bottom of the furnace. As the coke burns, carbon monoxide is produced and reacts with the iron oxides, yielding molten metallic pig iron and carbon dioxide. The limestone forms a slag on top of the molten iron and serves to reduce the concentration of silicon and phosphorous within the iron. Periodically, molten iron is tapped from the furnace and transported to the steelmaking unit.

Domestic blast furnace production in 1981 totaled 73.6 million tons. In the same year 120 million tons of raw steel were produced, implying that approximately 60 percent of all domestic steel was produced from pig iron.

The modern blast furnace represents 2,000 years of evolution in iron reduction technology. It is not likely that radical improvements will be made. One area where minor improvements are occurring is in energy management. For instance, off-gases from the process are collected and used to preheat furnace feeds, prereduce iron ores, and generate electricity. Further improvements in energy efficiency are expected.

Steelmaking

The actual steelmaking process is a refining step in which impurities are removed from the molten pig iron and steel scrap that are charged to the furnace and desired alloying elements are added. The three main steelmaking processes that are currently being used are the open-hearth process (OH), the basic oxygen process (BOP), and the electric arc process (EA).

Open-Hearth Process (OH)

In this process a shallow open hearth is initially charged with scrap, limestone, and iron ore and is heated by flames sweeping over the surface. Molten pig iron is then added after the scrap is partially melted. Hot fuel gases, with more than the amount of air required for combustion, are ignited and passed over the surface of the molten charge. The oxygen present in the iron ore as well as the excess oxygen in the hot gases serves to oxidize unwanted carbon, silicon, manganese, and phosporous. To speed the process, oxygen lances may be used to blow or inject pure oxygen into the melt.

The refining of a melt takes from 5 to 8 hours, and heats of 100 to 600 tons can be produced. The OH furnace is quite versatile in that it can utilize wide variations of scrap and molten iron in combination, with the actual scrap-to-hot-metal ratio depending on the relative prices and availability of the materials and on the capacity to produce pig iron. However, because of the long time required to refine a charge, the open-hearth process is steadily being replaced by the more efficient and economical basic oxygen and electric furnace processes.

Basic Oxygen Process (BOP)

The basic oxygen process can produce heats of up to 400 tons in about 35-45 minutes. The furnace--a closed-bottom, refractory-lined, pear-shaped vessel--is initially charged with molten pig iron, steel scrap, and slag formers. A supersonic stream of oxygen is directed into the melt through a water-cooled lance or tuyeres or both. This causes rapid oxidation of the unwanted constituents and refines the molten metal. During the oxygen blow lime is added to carry off the oxidized impurities and form a layer of slag in the melt. After the steel has been refined, the furnace is tapped or tilted and the molten steel pours into a ladle where alloy additions are made to finish the steel's specific composition. The basic oxygen process, which has largely replaced the OH, requires no fuels to combust the charge. The highly exothermic reactions in the vessel are a sufficient source of heat for the process as long as scrap additions are kept below about 30 percent.

Domestic BOP steel production in 1981 was 73.3 million tons, accounting for 60.6 percent of the year's total. BOP production has grown rapidly. In 1963 the BOP accounted for less than 10 percent of yearly steel production. Growth of the BOP can be attributed to its improved productivity and energy management over obsolete open-hearth furnaces.

Electric Arc Process (EA)

The EA process usually begins with an initial charge of 100 percent cold scrap. Graphite electrodes extending through the roof of the furnace are lowered to a point near the top of the charge and an electric arc is passed between them, melting the scrap charge. When scrap is partially melted, iron ore, limestone, and alloying elements are added to complete the charge. The following refining process is completed in 2 to 7 hours. With capacities of a few hundred pounds to 400 tons, the EA furnace (EAF) is primarily used to produce specialty steels such as stainless, high-alloy, and tool steels. However, the emergence of minimills using EA furnaces has increased the amount of carbon steel produced by this technique. In 1981 the EA process accounted for 28.3 percent of domestic steel production. Five years earlier EAFs produced less than 20 percent. Growth is expected to continue for the following reasons: The EA process is inherently more controllable than the BOP. Therefore, alloy, stainless, and other specialty steels are, and will continue to be, produced in the EAFs. In 1981, 100 percent of domestic stainless steel and 50 percent of the alloy steel were produced in the EAs. Scrap prices are currently less than half the price of pig iron. As long as prices remain low and good scrap remains available, scrap-charged EAFs will have considerable cost advantage over all other production technologies.

In spite of these advantages, there are inherent limits on the amount of steel that can be derived from scrap in the long run. Therefore, it is not expected that the EA process will surpass the BOP and become the dominant steelmaking technology.

Casting

In traditional practice the molten steel produced by any of the three processes mentioned above is poured into large molds to solidify and form ingots. The ingots are cropped and reheated in soaking pits and hot-rolled into semifinished shapes: either blooms, billets, or slabs.

The practice of strand, or continuous, casting is an alternative method that produces semifinished shapes directly from molten steels. Large energy and cost savings result from the higher product yields obtained (continuous casting, an average of about 79 percent versus ingot casting, 69 percent). In strand casting molten steel is poured from a tundish into a vertical water-cooled mold, which is open at the bottom. The cross section of the mold (sometimes adjustable) corresponds to that of the desired semifinished shape. As the molten steel descends the mold it forms a solid shell that contains the shape as it leaves the supports. It then enters a water-spray chamber where solidification is completed. The semifinished shapes are then roller-straightened and cut to shape.

Continuously cast steel output has been gradually increasing in the United States. In 1969 it accounted for only 2.9 percent of crude steel production; by 1975 its share had increased to 9.5 percent; and by 1983 about 30 percent of all raw steel produced was continuously cast.[3] Approximately half of this total was accounted for by minimills. In West Germany and Japan 53.6 and 70.7 percent, respectively, of total output was continuously cast in 1981.

Finishing

The slabs, billets, and blooms produced by casting are then processed into finished steel shapes by various mechanical rolling procedures. After reheating, blooms are processed into structural shapes and rails, while billets (often without reheating) are rolled into bars, wire, or seamless pipe. Slabs are made into hot and cold rolled sheet and strip, plates, or skelp.

Direct casting and continuous annealing operations are being developed to reduce the cost of finishing. Like continuous casting, these processes offer energy and labor savings through the elimination of separate batch operations (e.g., reheating, cropping, material handling). Additionally, continuous operations generally have higher process yields and are usually less labor-intensive. However, these technological innovations are capital-intensive and may be economically impossible even when technically desirable.

IMPORTANCE OF THE DOMESTIC INDUSTRY

The domestic steel industry is important to the economy and national security of the United States. With average annual sales of almost $60 billion over the period 1978 to 1983 and gross fixed assets (accounting value of property, plant, and equipment) of about $45 billion in 1983, it is one of the largest industries in the nation. The steel industry is also a major source of employment, with approximately 350,000 wage employees in 1983 (down from 456,000 in 1979) and about 150,000 salaried personnel.[4] The total of approximately 500,000 represents about 0.5 percent of the domestic work force. The U.S. integrated producers are centered in the East and Midwest, although there are production facilities located in 36 states.

In addition to the absolute size and direct employment of the industry, it is also important because as a basic input to other industrial sectors of the economy, including (1) manufacturing (particularly the automotive industry), (2) construction, (3) suppliers to the steel industry of equipment and raw materials, and (5) the approximately 20,000 metal fabricating plants that the steel industry supplies. It has been estimated that the direct employment figure of the steel industry may be multiplied by a factor of four to obtain an estimate of employment by industries directly dependent upon it for business in any given year.[5] This estimate is probably high since some indirect employment will exist at the same level whether the steel is produced domestically or imported.

There is no question that steel is critically important to the nation's defense-related industries. Almost every item of military hardware contains steel in some form, and there are no other materials that can provide the required properties at an acceptable cost. Moreover, industries that are vital to the military's need for equipment, transport, and support depend on steel to an important extent.

The national security also depends on a strong industrial economy, and the economic viability of the manufacturing sector is predicated upon a continuous and adequate supply of steel. There is no debate on the issue of whether we should maintain a steel industry capable of providing for a strong national defense. However, there is also no compelling reason for the United States to adopt policies aimed at maintaining a domestic industry capable of supplying 100 percent of peak demand.

One school of thought argues that it is not necessary from an economic or strategic point of view to maintain a large domestic steel industry. Since imports come from a large number of countries with varied geographical locations and political systems, the probability that any political coalition could be formed to deny the United States its requirement for steel is very small. Moreover, it is possible to shift consumption patterns away from consumer uses (e.g., steel for automobiles, containers, home appliances, and home construction) toward more essential defense-related requirements in the event of a protracted military emergency.

It has been estimated that during World War II steel shipments to military-related industries were at most 25 million tons (approximately 42 percent of total shipments) in each peak year. Estimates of steel shipments to industries serving postponable peacetime consumer needs in 1976 and 1977 were put at more than 30 million net tons (45 percent of total shipments). It is argued that adequate supplies of steel should be available to shift to military use in the event of an emergency.[6]

The other line of reasoning is that it is necessary to have a large and strong domestic steel industry capable of supplying a substantial share of domestic consumption in order to be prepared for all conceivable military events and to supply domestic consumers during the periods of peak demand without threats of price gouging and long order delays. However, there are no official estimates of the minimum domestic capacity needed for national defense. Periodically the essential character of the steel industry to the nation's security is affirmed, such as in the President's Materials Policy Commission[7] (Paley Commission) report in 1951 or President Carter's Program for the American Steel Industry, but the issue of "how much" has never been definitively addressed.

According to a recent National Science Foundation report:

> The closest we have to an official estimate of steel needs for national security is the unclassified relative breakdown of wartime requirements calculated by the Federal Emergency Management Agency (FEMA). These calculations indicated that for a 3 year non-nuclear war in 1979, given full mobilization beforehand, 26 percent of steel industry output would be required for direct military purposes and 56 percent would be required for essential uses in support of the military effort. The absolute tonnages are classified information but if we assume the calculations were based upon activity levels comparable to a prosperous steel year such as 1973 or 1974 . . ., they would imply that about 90 million tons of steel mill products would be required for direct military and essential support uses each year of the war or about 120 million tons of raw steel output.[8]

NOTES

1. The 29 unit processes found in various integrated steel parts are: ore yard, coal yard, scrap yard, sinter strand, coking facility, direct reduction unit, blast furnace, open-hearth furnace, basic oxygen furnace, electric furnace, conventional casting unit, continuous casting billet unit, continuous casting slab unit, primary breakdown to blooms, primary breakdown to billets via blooms, primary breakdown to slabs, heavy structurals and rails, bar and rod, wire products, cold finished bars, seamless pipe and tube, hot strip mills, pickling and oiling, welded pipe, cold reduction and finishing, galvanizing, tin plating and other plated products, plate mill, and ancillary facilities.

2. American Iron and Steel Institute, Annual Statistical Report, various years.
3. Ibid.
4. Ibid.
5. Arthur D. Little, Inc. (1981).
6. Crandall (1981).
7. President's Materials Policy Commission (1951).
8. Trozzo (1982).

2

Technology Assessment of the Domestic Steel Industry

Included among the major objectives of this study are the identification of global shifts in international technological capability and the assessment of future prospects for further technological change and industrial development. A technology assessment must consider the industry from at least three points of view:

- It must analyze separately the status of existing plants and operations in the three major industry segments--integrated mills, specialty steel producers, and minimills.
- It should consider the capabilities of the industry in the development and adoption of both new processes and new products.
- It must evaluate the manpower situation with respect to availability, skill level, and employment of scientists and engineers in ferrous metallurgy research and development.

Each of these points is discussed below.

EXISTING PLANT OPERATIONS

Integrated Steel Mill Operations

One of the key problems facing domestic integrated mills is that many of the plants are seriously outdated. In fact, as shown by Table 2-1, only two new greenfield plants (i.e., completely new facilities) have been built in the United States since 1950, and many of the old plants are in need of modernization. As a result, only about 10 percent of U.S. output of steel is produced in plants less than 32 years old. This is in sharp contrast to Japan, where almost all steel is produced in new plants, and to West Germany, France, and the United Kingdom, where over half the steel is produced in plants built or modernized since 1950.

TABLE 2-1 Large Integrated Steel Plants Built Since 1950 (approximately 2 million tons/year and over)

Country	Name (Location)	Millions of Metric Tons/Yr		
		New Plant Approx. Capacity	Country Subtotal	Total Raw Steel Production, 1978
Australia	–		–	7.6
Argentina	Somisa	2.65	2.65	2.8
Belgium	Sidmar	3.2	3.2	12.6
Brazil	Usiminas	2.4		
	CSN	2.5		
	Cosipa	2.2	7.1	12.2
Canada	–		–	14.9
China (PRC)	Nanking	2.0+		
	Paotou	2.0+		
	Wuhan	3.0+		
	Anshan	6.0	13.0+	31.0 (est.)
Czechoslovakia	East Slovak Works	3.6	3.6	15.3
Finland	Rautaruukki Oy	1.7	1.7	2.3
France	Solmer	3.5		
	Usinor-Dunkirk	8.0	11.5	22.8
W. Germany	Hoesch-Phoenix	4.2		
	Klöckner-Bremen	3.6		
	Krupp-Rheinhausen	5.4		
	Thyssen-Beeckerwerth	6.5		
	Thyssen-Bruckhausen	5.2	24.9	41.3
India	Bokaro	2.0		
	Bhilai	2.5		
	Durgapur	2.0		
	Rourkela	2.0	8.5	10.1
Italy	Italsider-Taranto	11.5	11.5	24.3
Japan	Kawasaki-Chiba	6.5		
	Kawasaki-Mizushima	12.0		
	Kobe-Kakogawa	8.0		
	Kobe-Kobe	3.5		
	Nippon-Muroran	4.4		
	Nippon-Nagoya	7.5		
	Nippon-Sakai	4.7		
	Nippon-Kimitsu	9.5		
	Nippon-Oita	8.4		
	Nisshin-Kure	3.1		
	NKK-Fukuyama	16.0		
	NKK-Ohgishima	6.0		
	Sumitomo-Kashima	9.0		
	Sumitomo-Wakayama	8.0	106.6	102.1
South Korea	Pohang	8.5	8.5	5.0
Poland	Nowa Huta-Krakow	3.5		
	Huta Katowice	4.5	8.0	19.3

TABLE 2-1 (Continued)

		Millions of Metric Tons/Yr		
Country	Name (Location)	New Plant Approx. Capacity	Country Subtotal	Total Raw Steel Production, 1978
Rumania	Galati	5.0	5.0	11.7
South Africa	Iscor-Newcastle	2.8	2.8	7.8
Spain	Ensidesa-Verina	2.4	2.4	11.3
Sweden	Granges Oxelosund (under restructuring)	2.0	2.0	4.3
Turkey	Eregli	2.0	2.0	2.2
United Kingdom	BSC-Ravenscraig	3.2		
	Scunthorpe-Anchor	4.6		
	Teesside-Lackenby	4.6		
	Llanwern-Newport	3.5	15.9	20.3
USSR	Cherepovets	3.0		
	Sverdlovsk	3.0		
	Karaganda	4.5		
	West Siberia	8.2		
	Trans Baikal	4.0		
	East Siberia-Svobodniy	3.0		
	Krivoi Rog (new plant)	8.5		
	Yenakiyevo	3.5	37.7	151.4
USA	Bethelehem-Burns Harbor	4.8		
	U.S. Steel-Fairless	3.0	7.8	124.0

SOURCE: Old, Holloway, and Tanenbaum (1981).

The advanced age of plants of the domestic steel industry leads to a number of problems. First, much of the equipment utilized in the 29 unit processes listed on page 18 is nearly obsolete. Many old coke ovens, sinter strands, blast furnaces, steel casting facilities, and bar mills are small, inefficient, and cannot be modernized without extensive capital investments. Thus, age of plant contributes to increased labor and energy costs and consequently higher production costs of certain products, which leads to added imports. Second, the spot replacement of individual unit processes by modern equipment often represents a piecemeal approach that may leave the plant out of balance and result in an incomplete solution to the overall problem. Third, the existing plant sites are ordinarily inadequate in area to permit a complete rebuilding to take maximum advantage of new technology and materials flow. Fourth, many old plant sites are no longer in locations favorable to raw material assembly or to the markets for their products.

In contrast to the United States, the Japanese in particular have been able to replace their entire steel industry since World War II by building 14 large, new greenfield plants. This has permitted them to utilize the latest technology, materials assembly, materials flow, and process control techniques. Furthermore, it has allowed them to make additional improvements by correcting unforeseen operating problems and to build upon this experience as each additional plant was laid out and constructed. Learning by doing has been a major factor in Japan's progress toward low-cost, high-quality steel production.

The major issue to be addressed at this point is the extent to which any U.S. production cost disadvantages can be attributed to inadequate technology. Most experts are in general agreement that lack of knowledge of technology is not the primary reason for any U.S. operating cost disadvantages, because advanced technology is readily available worldwide through licensing. However, having technological knowledge is of little value unless it is deployed through capital investment in new plants and equipment. The integrated steel industry is capital-intensive, requiring from $15 to $20 of capital investment in new plants and equipment to take advantage of every dollar invested in research and development. The rates of return in the integrated carbon steel industry have been too low to attract a significant amount of capital for reinvestment in steel capacity for many of the past 25 years. Reasons for the low profitability of the domestic integrated producers are discussed in Chapter 7.

The United States is aware of and uses to some degree essentially all of the world's most advanced technology. This is evident from the fact that, for each of the 29 unit processes that together constitute integrated steel production, one can find world-class operations in one location or more in the United States. The major problems do not stem from a lack of knowledge but from insufficient deployment of technology compared with some foreign competitors and the inability to justify the construction of revolutionary new greenfield plants. The preliminary design of a novel greenfield plant at Conneaut, Ohio, by the United States Steel Corporation in 1978 delineated the advantages in technical efficiency that could be attained by such an undertaking. However, the projected operating cost savings of about 33 percent did not offset the required capital costs. Characteristics and technological features of this plant are discussed in more detail in the following chapter.

Major technological developments that could be adopted by the steel industry have been identified in a number of recent reports.[1-3] These are summarized in Table 2-2 where the degree of adoption of each process by the steel industry over the next 20 years is postulated. The only two processes showing radical improvements, and quick adoption rates, are continuous casting and direct reduction, both of which were developed over 20 years ago. Even if unique technological advances that could have a significant effect on domestic steel costs do become available, if past licensing practices continue it is likely that such advances would be utilized abroad, thus blunting domestic advantages.

Minimill Operations

From the technological standpoint the minimill segment of the industry is also a world leader.[4,5] Scrap quality is superior, and preparation and handling are excellent. Experience has also been gained using up to 100 percent direct-reduced iron charge. In steelmaking the industry has pioneered the use of large, high-power electric furnaces and water-cooled roof and wall construction. Since most of the plants have been built since 1960, almost all employ continuous casting. And the industry finishing capacity is excellent, having introduced several new rolling methods, such as split rolling and very high speed rod mills. Labor is normally nonunion. Production costs are often lower than those of foreign mills, which usually face higher scrap and power costs. This segment of the domestic steel industry is rather free from import problems, except for a few products (e.g., wire rods).

INNOVATION CAPABILITIES OF THE INDUSTRY

The steel industry worldwide is quite different from many other industries in that few attempts are made to keep major

TABLE 2-2 New Technologies That May Be Adopted by the U.S. Steel Industry

Technological Process*	Category	Significant Adoption Possible Within: 5 Years	10 Years	20 Years	Principal Features
Plasma arc steelmaking*	1	–	–	?	Fast reactions, small units.
Direct steelmaking*	1	–	?	?	Eliminates cokemaking.
Liquid steel filtration	2	?	?	?	Improves product quality.
Continuous steelmaking*	1	–	?	?	Conserves energy and reduces number of reactor units.
Secondary refining systems*	2	X	X	X	Improves product quality.
Hydrometallurgy production of iron	1	–	?	X	Low-temperature processes.
Nuclear steelmaking*	1	–	–	?	Alternative energy sources for steelmaking.
Hydrogen systems*	1	–	?	X	Alternate fuel/energy source.
Direct reduction processes*	1	X	X	X	Low-temperature solid-state reduction of iron ore to iron.
Coal gasification*	4	?	X	X	Alternate fuel/energy source.
Preheating of coking coal/ pipeline charging	2, 3	X	X	X	Reduces pollution and conserves energy in cokemaking operation.
Dry quenching of coke	2, 3	X	X	X	Reduces pollution and conserves energy in cokemaking operation.
BOF/Q-BOP offgas utilization	2, 3	X	X	X	Energy conservation measure.
High top pressure BF electricity generation	2	?	?	X	Energy conservation measure.
Evaporative cooling	2, 3	X	X	X	Improved cooling system, saves water usage.

External desulfurization*	2	X	X	X	Allows improved product quality and increased blast furnace productivity.
Induction heating of slabs/coils	2	X	X	X	Reduces scale formation, increases yield, and conserves energy.
Catalytic reduction process	2	–	?	X	Used with coal-based reduction processes to increase reaction rate.
Blast furnace fuel injection	2	X	X	X	Use of alternative fuels to replace coke (possible energy conservation).
Direct casting of steel	1	–	?	X	Eliminates mechanical forming and heating.
Continuous casting	1	X	X	X	Direct conversion of liquid steel to solid slabs and squares. Major energy conservation measures and increased yield.
Formed coke	1	–	?	X	Replaces metallurgical coal/coke.
Biomass energy systems	2	–	?	X	Alternate fuel source.
Self-reducing pellets and briquettes	2	–	?	X	Iron ore/carbon flux is intimately mixed to allow reduction in the pellet.
Powder metallurgy steel sheet	1	?	X	X	No melting or reheating required (minimill concept)
Direct/inline rolling	2	?	X	X	Eliminates holding and reheating steps.
Computer modeling/control	2, 4	X	X	X	Applies to any unit-process operation.
High-temperature sensors	2, 4	X	X	X	Units to measure and control high-temperature ironmaking and steelmaking process variables.

*Includes a variety of processes.

DEFINITIONS: 1–radical; 2–incremental; 3–environmental; ?–significant adoption possible if pilot efforts show promise; X–significant adoption possible.

SOURCE: U.S. Congress (1980).

process improvements secret--instead, there is rapid and extensive diffusion of information, knowledge, and licensing between companies on an international basis.

The record of the steel industry worldwide in developing and adopting new processes over the past 30 years was studied and reported on in 1977.[6] The findings can be summarized as follows:

- Of the 23 process developments investigated, the United States and Japan led both in initiation and in first commercial use. Japan leads in percent of installed capacity utilizing basic oxygen furnaces and continuous casting (these capital-intensive installations have assisted Japan in increasing the efficiency of its large, integrated mills). The United States leads in AOD (argon-oxygen-decarbonization) capacity (this has increased the quality of U.S. specialty steels), and the USSR in electroslag remelting capacity. Process control and business systems have been developed largely in the United States, Japan, and the United Kingdom.
- The time required to transfer a technological development from the discovering nation to the second user is only one to four years (because of a tradition of rapid licensing of inventions on an international basis). Rate of adoption depends on comparative economic advantage, the need to expand capacity, and the availability of capital.
- The rate of adoption of new technologies in the United States slowed appreciably beginning in about 1970 because of capital shortages as imports grew and consumption leveled off.
- The United States has led the world until recently in the development and introduction of new steel products such as high-strength, low-alloy steels and plated and coated carbon steel products. This tends to increase market share and profits for domestic producers. Japanese R&D is now challenging this leadership.

The major advantage the Japanese have gained in integrated steel mill technology is the experience of planning, building, and operating a series of large greenfield plants during a period of expansion. The drive to achieve world leadership had the active support of the government, not only in financing but also in encouraging top graduating scientists and engineers to enter the steel industry. In addition, Japanese management gives much credit for the increased productivity gained to the labor force for its work ethic and constructive ideas. As a result, the Japanese have proceeded to attain world leadership in integrated mills by advances down the learning curve through a succession of greenfield engineering improvements.

The situation is quite different in innovation in the specialty steel segment of the steel industry, where the United States leads the world. Driven by the extraordinary demands of the defense, aerospace, and energy industries, the United States has long been the leader in alloy development to meet stringent requirements for strength, hardness, heat resistance, corrosion resistance, formability, etc. Tailor-making alloys for certain uses entails working closely with the customer and makes entry into the market more difficult for foreign producers. However, in large tonnage items like stainless steel, imports have caused domestic producers severe problems.

The melting and fabrication of specialty steels require special processes and careful quality control. The United States has also been a leader in this area, having introduced the AOD process, consumable electrode remelting, vacuum induction melting, powder metallurgy alloys, and other such innovations.

The minimill segment of the domestic steel industry also enjoys a reputation for innovation second to none. As previously mentioned, the industry has pioneered many advances in electric furnace operation and flexible and high-speed fabrication processes.

RESEARCH AND DEVELOPMENT

A comparison of the R&D capabilities of the United States and its leading steel-producing competitors such as Japan, France, West Germany, and the United Kingdom can best be made on the basis of numbers of research scientists and engineers employed. (Note: The USSR is omitted as it does not compete seriously in the U.S. market). This is logical because inquiries into academic and industrial organizations confirm that productivity in R&D, which depends on capabilities of research personnel, facilities, and working environment, is essentially equivalent in the field of ferrous metallurgy among the five leading nations.

Several recent reports[7] provide information on the numbers of research scientists and engineers employed in the iron and steel industries of the five nations. The information is summarized in Table 2-3.

It is apparent from Table 2-3 that Japan is now leading the world in size of ferrous metal R&D activities. In part this has been brought about by the Japanese national policy to promote the steel industry and encourage the brightest graduating science and engineering students to join the industry. The United States, the leader in the 1950s, is now second in size of effort. In the opinion of U.S. experts who have recently visited Japanese laboratories, Japan now surpasses the United States in theoretical

TABLE 2-3 Comparative National Ferrous Metal R&D Efforts

	Numbers of Research Scientists and Engineers in Ferrous Metal R&D				
	1967	1970	1975	1977	1978
Japan	4,450	4,880	5,480	5,710	5,760
United States	3,150	3,200	3,300	4,000	–
United Kingdom	2,880	2,450	1,570	–	–
West Germany	1,870	1,870	990	–	–
France	585	605	575	–	–

SOURCE: B. S. Old et al. (1981).

and applied physical metallurgy as well as process metallurgy. Japan is also able to transfer its findings effectively into commercial utilization. The technical leadership of the Japanese will increase the licensing of their developments in the United States. Evidence of this is already apparent through visiting teams of Japanese experts to assist U.S integrated steel mills in blast furnace operations, etc.

An exception to these statements might be made in the case of specialty steel R&D, where the United States is still the leader, although the Japanese are beginning to challenge seriously.

Future Processing

A review of the current state of iron and steel technology, ongoing steel processing research, and projected assessments of the future technology of the industry has lead to the conclusion that few new processes will be developed within the next 20 years that have a high probability of significantly altering the character of the U.S. steel industry. However, technological innovations will be made in many areas that will help increase productivity and reduce costs. Also, extensions of current trends will assist in upgrading the technological state of the steel industry.

The new processes that could have a significant impact on the competitive position of the domestic industry are classified in category 1 (i.e., radical) of Table 2-2. The common features of these new technologies are as follows.[8]

- A number of intermediate operations are combined into a single step, eliminating capital, materials, and labor requirements.
- Batch-type operations are replaced by continuous processes, increasing effective capacity and reducing capital and labor costs.
- More flexible operation and higher efficiencies are obtained at lower production levels (0.5 to 2.0 million metric tons per annum).

Two radical new technologies that are in early stages of development are direct steelmaking and near net shape casting. In direct steelmaking iron ore and a reductant, such as coal and oxygen, are combined in a vessel where the smelting reduction of the ore occurs. The result is molten steel in essentially a one-step operation. A number of government-sponsored projects investigating variants of this process are being worked on in Japan, Sweden, and West Germany. The elimination of the need for raw materials preparation, coke ovens, blast furnaces, and steelmaking furnaces could result in energy savings of 20 to 35 percent and capital cost reductions of 30 to 50 percent if the process is successful.[9]

There are also large economic benefits that would accrue from the development of direct (or near net shape) casting of steel sheet and/or strip (i.e., thicknesses in the range of 0.010 to 0.190 inches). Although continuous casting of sheet and strip directly from the melt has been successful for copper and aluminum, similar production techniques for steel have not been successful because of the high melting temperature and the mechanical toughness of strip. Currently, the U.S. Department of Energy is supporting a research and development program aimed at overcoming these technical problems. If this program is successful, it has been estimated that total cost savings of $70 to $200 per ton could be realized from reductions in energy, labor, and capital requirements.[10] [11]

Although these radical technologies could result in significant cost savings, both are speculative and long-term. Even if successful, they are unlikely to be implemented on a commercial basis before the mid-1990s.

SUMMARY OF TECHNOLOGY ASSESSMENT

Several important findings on the effects of technology and other factors emerged from the panel deliberations:

- In the integrated steel plant division of the steel industry there has been a global shift of technological leadership in the past 15 years from the United States to Japan. Since 1950 Japan has had the experience of building more new, large greenfield steel plants than any other nation. This experience, backed by government assistance and the largest ferrous metals R&D program in the world, permitted the Japanese to learn how to construct and operate the most efficient steel mills in existence.

However, technological preeminence does not always equate with economic leadership. Labor costs contribute 20 to 40 percent of total steel costs. A major factor in Japan's ability to export steel has been wage rates of approximately one-half those in the United States; now South Korea has built an integrated steel plant utilizing technology readily available from the world steel industry and is producing some carbon steel products at lower cost than the Japanese because of lower wage rates.

- By way of contrast, the United States has built only two new integrated steel plants since 1950. While the United States has dropped to second in R&D effort behind Japan, it is not lack of technological knowledge but inability to show the rates of return necessary to justify investments in known and developing technology that has prevented plant modernization and new construction. The U.S. industry must maintain a vigorous R&D investment in process and product development to offset as much as possible its high labor costs and lack of experience in new plant construction and operation and to be prepared, when economic conditions permit, to take maximum advantage of technological know-how by investment in new plants, processes, products, and equipment.
- The specialty steel division of the domestic steel industry has led the world in both process and product development, largely because of the stringent performance demands of the U.S. defense, aerospace, and energy industries. However, despite this technological leadership, the specialty steel division has suffered economic hardship, in part because of imports of stainless and tool steels. These imported products are sold at prices often alleged to be below the full costs of production (including an "adequate" return on investment) or below the exporting nation's own domestic prices. In any case, such imports have seriously eroded domestic profits by reducing the utilization rates of our specialty steel mills.
- The minimill division of the domestic steel industry is also an international leader in process technology. This has assisted in the expansion and profitability of the industry. However, there are other important factors. For example, the minimill division enjoys low scrap and power costs and high labor productivity compared with its international competitors. Moreover, minimills tend to serve local markets at a level of effectiveness that distant foreign competitors cannot meet.
- There do not appear to be great prospects for any radically new technologies that would be the salvation of the domestic integrated steel industry. Rather, the important factors will probably be incremental technological advances to reduce production costs, improve product quality, and increase services.

NOTES

1. U.S. Office of Technology Assessment (1980).
2. Szekely (1983).
3. Fitzgerald (1983).
4. Miller (1984a).
5. Miller (1984b).
6. Pitler (1977).
7. See Organization for Economic Cooperation and Development (1979); National Science Foundation (78-313); and Prime Minister's Office (1978).
8. Szekely (1983).
9. Ibid.
10. Flemings and Grant (1984).
11. General Electric Company (1984).

3

Comparative Domestic and International Production Costs

A number of reports on the steel industry have included estimates of international production costs. They are difficult to compare because methodologies differ (e.g., some are based on confidential cost data obtained from producers, others on accounting data from financial reports), assumptions differ (e.g., some assume 90 percent capacity utilization as the standard operating rate, others assume less), and time frames vary. Given the difficulties of comparison, it is possible to draw some general conclusions regarding relative production costs if one concentrates on two principal factors of cost competitiveness in the world market: the total local currency cost of steel products and the exchange rates used to translate foreign currencies into U.S. dollars.[1] Moreover, though the estimates are controversial, it is also useful to examine the trends in the relative productivity and costs of factor inputs in the United States and other countries. This chapter contains estimates of total production costs in major steel-producing countries, the effects of exchange rates on international cost competition, the costs of new plants, and comparative labor and materials costs among important producing nations. Finally, the potential costs of making steel by alternative technologies is analyzed.

COMPARATIVE TOTAL PRODUCTION COSTS

This section briefly reviews the recent evolution of total production costs among major steel producing countries. Table 3-1 compares estimates by seven separate sources of the total costs of producing steel in the United States and in Japan in 1976. These are average total costs of producing a representative finished carbon steel product mix in integrated mills in the United States and in Japan. They are average total costs in the sense that they include all labor, materials, capital, overhead, etc., and

TABLE 3-1 Estimates of U.S. and Japanese Total Production Costs, 1976 (dollars/net ton finished product)

Japanese Costs	U.S. Costs	Japanese Cost Advantage
262[a]	306[a]	44[a]
233[b]	330[b]	97[b]
241[c]	325[c]	84[c]
267[d]	328[d]	61[d]
282[e]	339[e]	57[e]
277[f]	320[f]	43[f]
256[g]	283[g]	27[g]

[a] Paine Webber Mitchell Hutchins, Inc. (1979).
[b] Mueller and Kawahito (1978).
[c] Merrill Lynch, Pierce, Fenner and Smith, Inc. (1977).
[d] Council on Wage and Price Stability (1977).
[e] Barnett (1977).
[f] Arthur D. Little, Inc. (1977).
[g] American Iron and Steel Institute, *Correction of Merrill Lynch Production Cost Estimates* (1977).

that they combine estimates of costs of production at individual plants into one measure. These figures do not include estimates of the cost of landing steel in the United States. It is interesting that there is reasonable agreement about total costs of production, even though estimates of costs of the factors of production (not shown) vary considerably.

Shown in Table 3-2 are estimates of the total cost of production in Japan made by the U.S. Department of Commerce to determine the trigger prices that were established in 1978. They are based on data supplied by six major integrated producers in Japan. The Japanese estimates were made in accordance with the legislative prescription for determining the constructed costs of production and may be slightly on the high side.[2] Table 3-2 also includes estimates of 1978 production costs by two sources.[3]

TABLE 3-2 Estimates of Total Production Costs, 1978 (dollars/net ton finished product)

	Japan[a]		United States	
Exchange Rate (yen/$)	240	226	–	–
Operating Cost	242	256	324[c]	319[d]
Capital Cost	59	63	30[c]	36[d]
TOTAL	300[b]	319[b]	354	355

[a] Trigger price calculations for second and third quarters of 1978.
[b] Includes about $24 in imputed profits.
[c] Crandall (1981).
[d] American Iron and Steel Institute (1981).

TABLE 3-3 Total Costs of Steel Production, 1982 (dollars per metric ton of carbon steel products shipped)

	United States		United Kingdom		France		Japan		West Germany	
Capacity utilization[a] (percent)	90	48	90	58	90	61	90	58	90	55
Labor	172	–	122	–	150	–	72	–	133	–
Materials	291	372	386	370	299	296	254	285	283	290
Financial expenses[b]	34	74	42	77	84	98	61	101	46	64
Total pretax cost	580	695	493	585	465	546	411	490	430	513
Total pretax profit	23	–	-11	–	-28	–	72	–	45	–

[a] The first column for each country presents estimates of what production costs would have been if capacity utilization was 90 percent. The second column contains estimates of costs at the rates of capacity utilization that actually existed in 1982.

[b] Depreciation, interest, and miscellaneous taxes.

SOURCE: Paine Webber Mitchell Hutchins, Inc. (1983).

These estimates show that the differential between the average total costs in the United States and Japan in 1978 was between 10 and 15 percent (depending upon the exchange rate) in favor of the Japanese.

Although production costs in the U.S. in the recent past were only moderately higher than those in Japan, widely believed to be one of the lowest-cost producers in the world, the competitive position of domestic producers had radically deteriorated by 1982. Table 3-3 shows estimates of comparative production costs in the five major developed countries in 1982 made by Paine Webber Mitchell Hutchins, Inc. (World Steel Dynamics).[5] The estimates are made at two rates of production: the average rate of capacity utilization that actually occurred in 1982 and a theoretical rate of 90 percent of estimated sustainable capacity. (However, calculations based on a 90 percent capacity utilization standard overstate the cost disadvantage of U.S. producers for two reasons: (1) U.S. firms are not as highly leveraged, on average, as foreign producers,[6] and (2) none of the major producers in the world experienced operating rates as high as 90 percent in more than 10 years.) According to these estimates the United States is a higher-cost producer, on average, than any of the other major producers, including France and the United Kingdom, at any rate of capacity utilization.

There are two primary reasons for the recent changes in the relative cost structure of steel producers in industrialized countries. First, exchange rates between the U.S. dollar and currencies of other countries changed drastically. Second, rates of capacity utilization declined in all countries in the 1981-1982 recession, and U.S. industry was affected the most (see Table 3-3).

TABLE 3-4 Average Total Pretax Production Costs and Exchange Rates in Selected Countries

Year	United States	Japan	West Germany	France	United Kingdom
1978	393	359	386	408	424
		(209)	(2.00)	(4.50)	(0.521)
1979	441	345	422	472	478
		(219)	(1.83)	(4.25)	(0.471)
1980	496	386	462	530	540
		(227)	(1.82)	(4.23)	(0.431)
1981	542	425	431	489	526
		(221)	(2.26)	(5.43)	(0.498)
1982	580	411	430	465	493
		(249)	(2.42)	(6.51)	(0.569)

NOTE: Exchange rates are expressed in terms of the home currency per dollar and are shown in parentheses below the production cost numbers. Production costs are expressed in dollars per metric ton and are calculated at a theoretical standard operating rate of 90 percent of capacity.

SOURCE: Marcus (1983).

Fluctuations in foreign exchange rates appear to have had the most profound impact on the relative costs of carbon steel production in the international community in the past few years. The average total costs of production in the major industrialized countries are shown in Table 3-4 for recent years. At the end of 1978 the Japanese cost (measured in dollars) was the lowest and the U.S. cost was only slightly higher (about 10 percent). By 1981, the strength of the dollar, particularly against the European currencies, created a substantial upheaval in the relative cost structure.[7] At that time the West Germans were challenging the Japanese as lowest-cost producers and only the United Kingdom was close to U.S. steel mills in terms of average total costs at standard operating rates.[8] From 1982 to 1984 the dollar continued to strengthen, making the U.S. industry even less competitive in the world market.

Before conclusions are drawn about the significance of the cost differentials, it must be emphasized that all of these estimates are for average total costs. There are a number of plants with production costs well above and below the average values. Arthur D. Little, Inc., conducted a study for the American Iron and Steel Institute (AISI) in which a confidential survey of interplant cost variability was conducted.[9] The results, which are summarized in Table 3-5, indicate that in 1979 between 2 and 10

TABLE 3-5 Variability of Average Costs Across Plants, 1979

Product	Total Plants Surveyed (number)	25% or More Above Average (percent of production)	15% or More Above Average (percent of production)
Cold-rolled sheet	22	4	4
Hot-rolled strip	25	1	4
Hot-rolled bars	37	5	10
Plate products	45	2	2
Heavy structurals	15	4	10

SOURCE: Arthur D. Little, Inc., private communication, 1983.

percent of U.S. finished steel output was produced in plants in which costs were at least 15 percent above the average, depending upon the product type.

It is interesting to compare the costs in the United States with those of Japan in the U.S. market. To calculate the total cost of Japanese steel landed in the United States, we add to the cost of production in Japan the cost of freight, handling, insurance, and the working capital cost of transit times. These were estimated to have been about $35 to $40 per net ton on the West Coast and $45 to $50 per ton to Great Lakes markets (by way of the St. Lawrence Seaway) in 1978.[10] A U.S. import duty of approximately 8 percent ad valorem must also be included.[11] Assuming an average Japanese cost of $310 per net ton in 1978 the average carbon steel product imported from Japan would have had a total landed cost of about $375 per net ton on the West Coast and about $385 per net ton in the Great Lakes area. If we use the relative cost estimates shown in Tables 3-1 through 3-4 and adjust for transportation charges, we arrive at the same conclusion: the average current practice inland steel plant was able to meet the full-cost price of Japanese producers in 1978 in the immediate home market of the U.S. plant. However, those domestic plants with costs significantly above the average (say 15 percent) would have had difficulty covering a substantial part of their fixed costs at the Japanese full-cost price.[12] The data shown in Table 3-5 therefore suggest that on the order of 20 percent of the domestic capacity that existed in 1980 (total raw steel capacity was about 154 million net tons in 1980) would be retired in the future because it could not meet competitive import prices.

This is approximately the level of capacity that would have closed had conditions not changed so drastically in 1981-1982. The recession and strength of the dollar in the past few years have exacerbated the weak competitive position of U.S. mills to such an extent that in excess of 15 percent of domestic capacity was shut down between 1981 and mid-1984, although a precise estimate is not possible since some firms have not yet written closed facilities off of their books. It is likely that some 25 to 30 percent of the capacity that existed in 1980 will remain permanently closed. This means that from a base of about 154 million net tons in 1980, approximately 39 to 46 million net tons of raw steel capacity will be lost when equilibrium is finally reached. If one assumes an average yield of 80 percent, a loss in raw steel capacity of 39 to 46 million net tons translates into a loss of finished steel production capability of 31 to 37 million net tons, leaving the United States with the capacity to produce roughly 86 to 93 million annual tons of steel products.

COSTS OF NEW INTEGRATED PLANTS

The projected costs of building new integrated carbon steel plants in the United States is a matter of more controversy than are current costs. Table 3-6 shows three estimates of production costs in existing and new (greenfield) plants in the United States. It matters a great deal which estimate is taken as correct. If the AISI[13] estimate is correct, new plants would be able to compete with existing mills and, under the optimistic assumptions of substantial growth in the capital goods sectors, a strong recovery of world steel prices and a weaker dollar might be constructed in the United States in the future.

On the other hand, if Crandall's[14] estimate of production costs at new plants is more accurate, then at $425 per ton (1978 dollars), a new plant's cost of production is so high that it could not be expected to meet Japanese (or international) import prices. The estimates made by World Steel Dynamics[15] are in rather close agreement with those of Crandall even though they are not in equivalent dollars. If the differential between established and new plants of $80 per ton (1980 dollars) is deflated by 10 percent per year for two years, an appropriate differential of $65 per ton is derived in 1978 dollars. This is roughly equivalent to the estimate of $71 per ton arrived at by Crandall.

It should be noted that the domestic industry has not found economic conditions to be conducive to building a greenfield integrated facility in over 20 years. The last was Bethlehem's Burns Harbor plant, completed in 1963.

The preliminary United States Steel Corporation design of a novel greenfield plant at Conneaut, Ohio, in 1978 offers the best recent example of the possible effect of advanced technology on the economics of steelmaking in the United States:

Beginning about 1975, the United States Steel Corporation sent engineers to study the major innovations worldwide in all of the 29 unit processes employed or contemplated for utilization in

TABLE 3-6 Estimated Costs of New Integrated Carbon Steel Plants in the United States

	AISI (1978 dollars)[a]			Crandall (1978 dollars)[b]			World Steel Dynamics (1980 dollars)[c]		
	Established Plant	New Plant	Difference	Established Plant	New Plant	Difference	Established Plant	New Plant	Difference
Operating cost	319	226	-93	324	264	-60	422	351	-71
Capital cost	36	129	+93	30	161	+131	25	176	+151
TOTAL	355	355	0	354	425	+71	447	527	+80

[a] American Iron and Steel Institute (1981).
[b] Crandall (1981).
[c] Marcus (1981).

integrated steel plants. With the knowledge developed the corporation proceeded to undertake a preliminary design of a new greenfield steel mill and to obtain a permit for its construction from the Army Corps of Engineers, the Environmental Protection Agency and other pertinent federal departments.[16] The proposed plant design attracted the attention of steel experts from all nations. In brief, the plant was to have the following characteristics and technological features:

- The plant is to be located on deep water within economical shipping distance of both the major raw materials required and the principal markets for its products and within an area representing a good labor market and favorable living conditions.
- Rapid bulk lake carriers will be used to unload iron ore and limestone, with rail unloading for metallurgical and steam coal, storage facilities, and belt conveyors to move materials to next operations.
- There will be four coke batteries (3.6 million tons per year) each having forty-two 8-meter-high slot ovens, with provision for flash drying and preheating of washed, pulverized, and blended coal as well as a coal chemical plant.
- A continuous belt-fed sinter plant will produce 265 tons per hour of self-fluxing sinter from fine iron ore, dust, millscale, coke, and limestone.
- Two 10,200 tons per day, 47.2 ft. hearth diameter, high top pressure blast furnaces will be equipped with a computer-controlled conveyor feeding to a Wurth top. Hot metal will be cast into 330-ton ladles for transfer of desulfurized product to the adjacent steelmaking shop, thus avoiding railroad use within the plant entirely.
- Steelmaking facilities will consist of three 330-ton Q-BOP furnaces producing 62 heats per day or 7.5 million tons per year. The charge of about 86 percent hot metal, 12 percent scrap, and 2 percent coolant ore will balance the generation of in-plant scrap, avoiding scrap purchase. CO-rich off-gas will be collected.
- The continuous casting plant will consist of six dual-strand slab casters, each casting about 1.4 million tons annually of slabs up to 76 inches wide for the production of sheet, strip, and plate. About 75 percent of capacity will be processed through the hot strip mill and 25 percent through the plate mill. Yield will exceed 93 percent.
- The hot strip mill will have a capacity of 5.0 million tons of hot bands per year up to 0.50 inches thick. It will consist of slab reheating furnaces, roughing train with two four-high tandem reversing mills, finishing train consisting of seven four-high mills, runout table, and three downcoilers. The entire mill from the furnaces to coilers is automated with a total process operation-

control computer to provide inventory, specification, dimension, location, scheduling, and other support information required by operators. Finishing facilities, such as shear and slitting lines, recoilers, temper mills, etc., will also be included.

- The plate mill will have an annual capacity of 1.5 million tons per year in sizes up to 2 inches thick, 154 inches wide, and 98 feet long, with an effective yield of 85 percent. The steps entail slab conditioning, storing and reheating, hot rolling in roughing and finishing strands, cooling, quality conditioning, shearing, heat treating, cutting, and shipping by rail or truck.
- The overall yield from 7.5 million tons per year of liquid steel to shipped products is expected to be 85.75 percent, with 2.5 percent mill and scarfing scale and dust and 11.75 percent home scrap. This compares very favorably with yields of the best plants in the world. The tons produced per employee (total employees) are estimated to be 890, which is about double the best plants in the United States and equivalent to world-class plants.

Despite the expected halving of labor utilized per ton of steel produced due to the use of advanced technology, the project did not appear to be economically attractive because of high capital costs. The total cost of the plant was estimated (by Arthur D. Little, Inc.) to be over $800 per annual ton of shipments, of which about 20 percent was required to meet various federal and state regulations. Even though this figure might appear low (finishing mill capacity was not included in the project), the projected cost of servicing this debt more than offset the estimated saving in labor costs.

COMPARATIVE LABOR COSTS

When the Japanese and parts of the European steel industries were rebuilt in the early 1950s, dramatic gains were made in labor productivity due to the use of new technology and efficient plant design and layout. However, as shown by Tables 3-7 and 3-8--which compare international labor productivity at actual and standard operating rates--the United States still enjoyed a productivity advantage into the 1970s. By 1979, although the United States still compared favorably with France and the United Kingdom, Japan and West Germany enjoyed a productivity advantage at both standard and actual operating rates.

Actually, although the U.S. industry appears to have lost its position as the most efficient in terms of labor productivity, it still is among the world's leaders in this category. However, the major problem lies in the comparative total costs of labor rather than in the productivity of labor. As shown in Table 3-8, in 1978

TABLE 3-7 Labor Productivity at Actual Operating Rates (employee hours required per short ton of carbon steel shipped)

Year	United States	Japan	West Germany	United Kingdom	France
1964	12.32	26.03	22.39	25.43	25.61
1972	10.61	11.85	13.44	19.59	16.32
1973	10.15	9.49	12.08	18.40	15.36
1974	9.97	9.33	11.34	19.99	14.76
1975	10.63	10.08	12.64	23.17	17.15
1976	10.30	9.16	11.89	21.02	15.75
1977	10.62	8.91	11.87	21.69	14.85
1978	9.84	8.39	10.77	20.37	13.34
1979	9.97	7.58	9.79	18.86	12.07
1980	10.37	7.33	9.85	21.45*	11.59
Percentage of average annual change: 1964-1980	-1.08	-7.92	-5.13	-1.06	-4.96

*Estimates for 1980 are based on a comparison of the last 9 months of 1980 with the same period in 1979 because of the nationwide work stoppage in January through March 1980.

SOURCE: U.S. Department of Labor, Bureau of Labor Statistics, unpublished data.

total hourly compensation paid to steelworkers in the United States was about 25 and 40 percent higher than that paid to their West German and Japanese counterparts, respectively. These differentials have been exacerbated in recent years because of the effects of the strong dollar on exchange rates. By early 1983, despite an agreement between the industry and the steelworkers' union that temporarily reduced wages by $1.25 per hour and decreased the cost of certain benefits,[17] labor costs in the United States were more than twice as high as those in Japan and West Germany.

Average hourly earnings and total compensation for steel industry employees and for the average of all manufacturing workers for the past 20 years are shown in Table 3-9. Two conclusions are reasonably clear from these data. First, fringe benefits--including paid holidays, retirement pensions, unemployment benefits, and health and life insurance--account for a major proportion of domestic steelworker employment costs. Benefits in the United States currently average about 75 percent higher than benefits in other countries. (However, this differential may not be as large as noted since many benefits abroad are paid publicly rather than privately.) Second, domestic steelworkers' wages have been rising much faster than the average manufacturers' wages since 1971. The U.S. steelworker wage exceeded the average manufacturer wage by 76 percent in 1981 (in 1982 the premium was 89 percent).[18] Steelworkers in other countries also earned more than the average manufacturing wage (Table

TABLE 3-8 Comparison of International Labor Productivity at 90 Percent Theoretical Operating Rates (dollars/metric ton)

	United States			Japan			West Germany		
Year	Man-Hours per Ton	Employment Cost per Hour	Employment Cost per Ton	Man-Hours per Ton	Employment Cost per Hour	Employment Cost per Ton	Man-Hours per Ton	Employment Cost per Hour	Employment Cost per Ton
1969	11.5	5.5	63.5	17.2	1.7	28.4	12.2	2.4	28.7
1970	11.3	5.8	65.7	15.3	1.9	28.6	12.9	3.1	39.6
1971	10.8	6.5	70.4	15.0	2.1	31.9	12.3	3.5	43.0
1972	10.1	7.3	74.1	14.0	2.9	39.9	10.8	4.2	45.5
1973	9.8	7.9	77.4	12.3	4.1	49.9	10.8	5.7	61.3
1974	9.7	9.3	90.3	11.1	5.0	55.3	10.7	6.6	70.8
1975	10.2	10.8	110.4	10.8	5.4	58.6	10.0	7.8	77.5
1976	9.4	12.2	114.5	10.1	5.7	56.8	9.9	8.2	80.8
1977	9.5	13.4	128.0	9.2	6.7	60.9	10.1	9.6	96.4
1978	8.9	14.7	130.8	8.4	8.9	74.5	9.7	11.8	114.3
1979	9.0	16.4	147.0	7.8	9.2	72.0	8.8	13.8	121.2
1980	9.0	19.1	171.8	7.4	9.7	71.4	8.8	15.2	132.8
1981	8.7	20.8	181.0	7.1	–	–	8.5	–	–

SOURCE: Paine Webber Mitchell Hutchins, Inc. (1981, 1983).

TABLE 3-9 Hourly Labor Costs in the United States Steel Industry and in All Manufacturing, 1961-1981

	Hourly Earnings[a] (dollars)			Total Compensation for All Employees (dollars)		
	Steel Industry		Manufacturing	Manufacturing	Steel	Steel[b]
Year	BLS	AISI	BLS	BLS	WSD	AISI
1961	3.20	3.24	2.32	2.95	–	3.99
1962	3.29	3.33	2.39	3.06	–	4.16
1963	3.36	3.39	2.45	3.16	–	4.25
1964	3.41	3.43	2.53	3.29	–	4.36
1965	3.46	3.54	2.61	3.35	–	4.48
1966	3.58	3.64	2.71	3.50	–	4.64
1967	3.62	3.66	2.82	3.68	–	4.76
1968	3.82	3.86	3.01	3.94	–	5.03
1969	4.09	4.12	3.19	4.20	5.54	5.38
1970	4.22	4.24	3.35	4.50	5.83	5.68
1971	4.57	4.57	3.57	4.78	6.51	6.26
1972	5.15	5.22	3.82	5.03	7.33	7.08
1973	5.56	5.69	4.09	5.39	7.89	7.68
1974	6.38	6.55	4.42	5.95	9.29	9.08
1975	7.11	7.23	4.83	6.66	10.83	10.59
1976	7.86	8.00	5.22	7.22	12.18	11.74
1977	8.67	8.91	5.68	7.83	13.44	13.04
1978	9.70	9.98	6.17	8.47	14.73	14.30
1979	10.77	11.02	7.13	–	16.39	15.92
1980	11.84	12.11	7.75	–	19.06	18.45
1981	13.11	13.43	8.52	–	20.78	20.16
1982	13.96	14.06	8.50	–	24.67	23.78

BLS, Bureau of Labor Statistics.
AISI, American Iron and Steel Institute.
WSD, World Steel Dynamics.
[a] BLS data exclude office, clerical, and supervisory personnel.
[b] Nonsalaried workers.
NOTE: Data for 1961-1978, except for the WSD data, are from Crandall (1981).

SOURCES: Selected issues of the *Annual Statistical Report*, American Iron and Steel Institute, which contain the BLS and AISI data. WSD data from Paine Webber Mitchell Hutchins, Inc. (1981).

3-10), but the differential was much less pronounced. It is also interesting to note that the difference in labor costs between the United States and Japan accounts almost exactly for the difference in total costs between the two countries in the comparative statistics presented in Table 3-3. An earlier study by Arthur D. Little, Inc. arrived at a similar conclusion.[19]

It must be recognized that a major competitive disadvantage facing the United States and all other industrialized nations in the future is the relative cost of labor. Labor costs in most developing countries are in the $2 to $4 per hour range (e.g., approximately $4 per hour in Mexico, $3 per hour in Brazil, and $2 per hour in Korea). With labor costs comprising between 20 and 40

TABLE 3-10 Comparison of Steel Industry and Average Wages of Manufacturing Industries, 1975-1981

	1975	1976	1977	1978	1979	1980	1981
United States							
All manufacturing	6.35	6.93	7.59	8.30	9.08	10.00	11.05
Iron and steel	10.24	11.23	12.31	13.56	15.15	17.48	19.42
% Premium	61.30	62.10	62.20	63.40	66.90	74.80	75.60
Japan							
All manufacturing	3.05	3.30	4.03	5.54	5.49	5.61	6.23
Iron and steel	5.03	5.36	6.50	8.90	8.74	9.18	10.15
% Premium	64.90	62.40	61.30	60.60	59.20	63.60	62.90
Canada							
All manufacturing	6.11	7.20	7.54	7.69	8.15	9.04	9.86
Iron and steel	7.47	8.95	9.57	9.99	10.62	11.61	12.63
% Premium	22.30	24.30	26.90	29.90	30.30	28.40	28.10
West Germany							
All manufacturing	6.19	6.60	7.79	9.65	11.26	12.26	10.47
Iron and steel	7.12	7.50	8.68	10.74	12.66	13.53	11.46
% Premium	15.00	13.60	11.40	11.30	12.40	11.20	9.50
France							
All manufacturing	4.58	4.76	5.31	6.54	7.90	9.23	8.28
Iron and steel	5.86	6.11	6.89	8.02	9.54	10.86	9.74
% Premium	28.00	28.40	29.80	22.60	20.80	17.70	17.60
United Kingdom							
All manufacturing	3.27	3.12	3.35	4.28	5.50	7.37	7.43
Iron and steel	3.90	3.76	4.05	5.30	6.76	8.62	8.99
% Premium	19.30	20.50	20.90	23.80	22.90	17.00	21.00
Italy							
All manufacturing	4.60	4.38	5.08	6.09	7.19	8.26	7.59
Iron and steel	5.85	5.29	5.98	7.35	8.62	9.75	8.97
% Premium	27.20	20.80	17.70	20.70	19.90	18.00	18.20
Belgium							
All manufacturing	6.54	7.03	8.46	10.39	12.02	13.18	11.13
Iron and steel	8.09	8.79	10.83	13.34	15.62	17.13	15.06
% Premium	23.70	25.00	28.00	28.40	30.00	30.00	35.30
Netherlands							
All manufacturing	6.53	6.98	8.15	9.98	11.47	12.17	10.25
Iron and steel	8.18	8.66	9.85	11.76	13.89	14.83	12.48
% Premium	25.30	24.10	20.90	17.80	21.10	21.90	21.80
Luxembourg							
All manufacturing	6.34	6.86	7.99	9.81	10.98	11.81	–
Iron and steel	7.14	7.63	8.95	10.96	12.25	12.90	–
% Premium	12.60	11.20	12.00	11.70	11.60	9.20	–

SOURCE: Bureau of Labor Statistics.

TABLE 3-11 Comparative International Materials Costs, 1969-1982

Year	United States	Japan	West Germany	France	United Kingdom
1969	92	78	76	87	85
1970	100	82	86	90	92
1971	106	87	97	97	106
1972	110	90	102	103	109
1973	118	100	125	125	122
1974	157	140	170	168	169
1975	186	167	210	212	213
1976	199	175	208	205	201
1977	215	194	223	211	229
1978	233	218	241	231	265
1979	262	220	262	268	319
1980	298	261	291	302	441
1981	329	290	286	298	387
1982	373	285	290	296	370

SOURCE: Paine Webber Mitchell Hutchins, Inc. (1981, 1983).

percent of the cost per ton of finished steel (depending on the product type and shape), it will be difficult in the longer term for industrialized countries to compete for lower-technology carbon steel production.

COMPARATIVE MATERIALS COSTS

Comparative materials costs for the United States and four other major producing countries are shown in Table 3-11. An examination of Table 3-3 reveals that materials costs represent between 50 and 70 percent of the total cost of making steel. The major components of materials costs are (1) iron ore and scrap, (2) coking coal, and (3) other forms of energy (fuel oil, electricity, noncoking coal, natural gas), representing about 45, 35, and 20 percent of the total, respectively.

There is usually poor agreement among the various published estimates of the costs of factors of production, particularly materials costs. However, even given this uncertainty, it is clear that the United States no longer enjoys the materials cost advantage that it did in the mid-1950s and that we now have higher materials costs than either Japan or West Germany.

The differential in the cost of materials between the United States and Japan can be attributed to three primary factors other than exchange rates:

1. development of low-cost sources of iron ore and coking coal outside the United States,

2. declining rates for bulk ocean shipping, and
3. greater steelmaking yields in Japan.

Throughout the 1950s the United States enjoyed a significant raw materials cost advantage over its international competitors due to low-cost domestic sources of iron ore and coking coal. By the 1960s, however, the grade of domestically produced iron ore had declined and high-grade sources had been developed elsewhere. The Japanese in particular made investments to overcome their inherent raw materials disadvantage by constructing large, efficient plants with access to deep-water ports. In addition, they invested in countries such as Australia and Brazil to guarantee their security of supply. Today it is cheaper for the Japanese to import high-quality ore from Brazil and Australia than it is for the United States to transport lower-grade ore from Minnesota to the lower Midwest or the eastern states. Recent data indicate that coal mined in Australia and Canada in large open-pit mines is less costly than that mined domestically by a 3 to 1 margin.[20] The average cost of iron ore production in Brazil was recently reported to be about $7.50 per ton.[21] The delivered price of iron ore pellets was about $50 per ton in the United States and about $35 to $39 per ton in the international market.

POTENTIAL FUTURE COSTS OF MAKING STEEL

The comparative future costs of making steel products in the United States and in other countries is the most important factor for an assessment of the competitive position of the domestic industry. More specifically, one would like to make realistic judgments about issues such as the following:

- the likely future costs of making steel by alternative processing routes, making assumptions about technological requirements and costs of factor inputs;
- the percentage of the U.S. cost disadvantage that is accounted for by factors such as labor cost and technological disadvantage.

These are difficult issues without clear-cut solutions. Therefore, it is essential that they be addressed in as objective and consistent a manner as possible. To aid in this assessment, an engineering simulation model of the steel production process was developed by the Materials Systems Laboratory at the Massachusetts Institute of Technology (MIT). In the model, which is one of several simulation models of steel production, steelmaking is divided into 11 unit operations, and separate cost estimates are generated for each operation. These unit operations are:

(Feedstock Preparation)
1. Sintering Ore
2. Pelletizing Ore
3. Coking of Coal

(Reduction of Ore)
4. Blast Furnace (2 technologies)
5. Direct Reduction (natural gas & coal-based)

(Refining)
6. Basic Oxygen Furnace (2 technologies)
7. Electric Arc Furnace (ore- & scrap-based)

(Processing of Steel)
8. Casting of Ingots
9. Primary Milling of Ingots
10. Continuous Casting
11. Finish Milling of Steel Products

Four categories of cost input are accounted. These are (1) process materials, (2) energy, (3) overhead and labor, and (4) by-product credits. Finished steel products (sheet, rail, etc.) can be produced by alternative combinations of the listed unit operations. Five different combinations of these operations are considered within the model, with each one representing a commercially viable approach to producing steel products. These combinations are:

1. Coke, Pellets, Sinter → Blast Furnace → Basic Oxygen Furnace → Ingot Casting → Ingot Mills → Finishing Mills
2. Coke, Pellets, Sinter → Blast Furnace → Basic Oxygen Furnace → Continuous Casting → Finishing Mills
3. Pellets → Direct Reduced Iron (1) → Electric Arc Furnace → Continuous Casting → Finishing Mills
4. Pellets → Direct Reduced Iron (2) → Electric Arc Furnace → Continuous Casting → Finishing Mills
5. Steel Scrap → Electric Arc Furnace → Continuous Casting → Finishing Mills

TABLE 3-12 Costs of Feedstock Preparation
(basis: 1 short ton of output)

Cost Category	Pelletizing	Sintering	Coking
Process materials	$39.24	$36.43	$ 79.75
Energy	5.47	7.46	22.54
Direct labor	4.31	5.82	9.72
Capital	9.48	8.85	48.94
Other	3.22	3.03	15.06
By-product credits	–	–	(33.13)
TOTAL	$61.72	$61.59	$142.88

The difference between combinations 3 and 4 is the type of direct reduction technology employed--gas or coal-based. The cost model provides the means for performing consistent comparisons of the competitiveness of these technologies when making alternative assumptions about requirements for various forms of capital, labor, or materials, or about the costs of these factor inputs. These estimates are provided as examples of the comparative costs of the important stages of various steelmaking operations in the United States. They are thought to be sufficiently representative to permit a sensitivity analysis of the relative importance of the unit operations and factors of production.

The art/science of producing steel is known to have existed since 2000 B.C. There have been (and are) hundreds of variations in the steelmaking process. No single technology is clearly optimal. Rather, the best technology depends on the cost, availability, and quality of raw materials, energy, investment capital, and human resources. The "optimal" technology has varied regionally and through time. These are some of the reasons why five alternative production technologies are considered within the cost model. Comparing alternatives under a variety of scenarios enables relationships between cost, technology, and factor inputs to be better understood.

Technological improvement in steel production continues. Since steelmaking is a very mature industry, process improvements generally occur as a result of economic pressures. As the relative costs of factor inputs change, the focus of technological innovation shifts, always trying to minimize those factors that are most costly. Through scenario analysis, the cost model can be used to assess (1) the impact of changes in steelmaking and (2) which of the available technologies would be favored by shifts in the costs of factor inputs.

The estimated costs for the unit operations in feedstock preparation, primary reduction, refining, and finishing of steel are presented in Tables 3-12 to 3-15. These estimates are based on the data for input requirements for the unit operations shown in

TABLE 3-13 Costs of Primary Reduction (basis: 1 short ton of output)

Cost Category	Blast Furnace	DRI (gas)[a]	DRI (coal)[b]
Process materials	$ 96.53	$ 87.62	$ 88.24
Energy	83.16	79.04	34.03
Direct labor	5.82	3.69	4.20
Capital	19.48	20.46	27.65
Other	7.66	7.78	9.28
By-product credits	(15.63)	(1.45)	(4.03)
TOTAL	$197.01	$197.13	$159.38

[a] DRI (gas) = Direct reduced iron using natural gas.
[b] DRI (coal) = Direct reduced iron using coal.

TABLE 3-14 Costs of Refining (basis: 1 short ton of output)

Cost Category	BOF[a]	EAF (DRI1)[b]	EAF (DRI2)[c]	EAF (scrap)[d]
Process materials	$207.59	$217.53	$186.30	$117.67
Energy	1.58	34.98	34.13	26.25
Direct labor	8.55	15.54	15.54	15.54
Capital	9.73	15.04	15.04	16.26
Other	5.26	7.28	6.90	6.33
TOTAL	$232.71	$290.37	$257.91	$182.05

[a] BOF = Basic oxygen furnace.
[b] EAF (DRI1) = Electric arc furnace using direct reduced iron (gas-based).
[c] EAF (DRI2) = Electric arc furnace using direct reduced iron (coal-based).
[d] EAF (scrap) = Electric arc furnace using scrap.

TABLE 3-15 Costs of Primary Milling, Slabs (basis: 1 short ton of output; input: blast furnace-basic oxygen furnace steel)

Cost Category	Ingot Casting	Continuous Casting
Process materials	$269.73	$244.34
Energy	8.68	4.34
Direct labor	17.10	10.04
Capital	6.49	9.11
Other	8.00	5.47
By-product credits	(11.36)	(4.52)
TOTAL	$298.64	$268.77

TABLE 3-16 1983 Costs of Steelmaking, Hot-Rolled Sheet
(basis: 1 short ton of output)

Cost Category	Steel 1	Steel 2	Steel 3	Steel 4	Steel 5
Process materials	$148.34	$136.19	$ 97.88	$ 96.93	$122.78
Energy	21.15	15.98	136.88	91.72	41.58
Direct labor	83.43	75.09	77.04	77.56	67.43
Capital	102.06	99.93	85.97	93.03	54.08
Other	46.75	41.67	37.70	38.72	24.47
TOTAL	$401.73	$368.86	$435.47	$397.96	$310.34
RANK	4	2	5	3	1

Appendix B in Tables B-2 through B-15 and on the cost of factor inputs given in Table B-1. The costs of producing hot-rolled steel sheet by each of the five steelmaking paths outlined earlier are compared in Table 3-16.

It can be seen that when one makes the assumptions regarding technology mix, technological requirements, and costs of factor inputs shown in Tables B-1 through B-15 of Appendix B, the most cost-effective process is sequence 5, melting steel scrap in the electric arc furnace and employing continuous casting. It should be noted that the price of scrap in the model (about $90/ton), although in accordance with 1983 prices, is low by historical standards.

The cost of making steel varies regionally and through time. The cost estimates presented above correspond to generic domestic production technologies in 1983. To project the future costs of producing iron, steel, and steel products, the cost inflators and the associated rates of growth shown below were employed. These numbers represent the average of recent forecasts of several commercial macroeconomic models.

Inflator	Percent Increase/Year
Raw materials	3.9
Electricity	7.2
Fuels	9.2
Labor	5.9
Physical plant	7.8

Where these inflators were applied to the five alternate routes for making hot-rolled steel sheet, the cost estimates shown in Table 3-17 were obtained in nominal (1995) dollars. These can be converted into 1983 dollars with estimates of the rate of inflation.

From Table 3-17 the relative cost competitiveness of each technology is seen to remain essentially unchanged. This suggests that unless significant changes occur in the other technologies, TABLE 3-17 1995 Costs of Making Hot-Rolled Sheet (basis: 1 short ton of output)

Process Route	Cost ($/ton)	Rank
Steel 1	857	3
Steel 2	782	2
Steel 3	958	5
Steel 4	858	4
Steel 5	623	1

the electric-furnace continuous-casting processing route will dominate domestic production by 1995. However, it should be noted that the price of scrap could increase as electric furnace production expands because of the increased demand. This condition is not reflected in the estimates of Table 3-17, since the scrap price is inflated at the same rate as other raw materials.

The future costs of making steel under four separate sets of assumptions were also simulated with the model. One simulation employed the assumption that evolutionary improvements in current practice production by the integrated route would occur over time. In another simulation the cost of producing steel outside of the United States under the most favorable conditions was estimated. Finally, the cost of producing steel in an electric furnace in the United States, using scrap as the raw material, was evaluated. The assumptions for each scenario appear below. For comparison, the cost of producing steel in the United States by conventional integrated production technology is included.

In the simulations all of the process improvements are assumed to occur on a continuous basis over the range of projections (18 years). In the year 2001 the full extent of the improvements is realized.

Simulation 1--Current U.S. Integrated Steel Production

- Technology: coking, pelletizing, sintering → blast furnace → BOF → continuous cast → finish mill
- No process improvements
- Cost of factor inputs: Changes according to the cost inflators shown above.

Simulation 2--Evolutionary Change U.S. Producer

- Technology: coking, pelletizing, sintering → blast furnace → BOF → continuous cast → finishing operations

- Process Improvements:
  1. 10 percent decrease in raw materials consumption
  2. 20 percent decrease in electricity consumption through better process control and employment of continuous annealing
  3. 20 percent decrease in labor burden through automation
  4. 15 percent reduction in energy consumption, primarily through automation and continuous processing
- Additional costs: 10 percent higher capital costs to cover investments in process improvements
- Cost of factor inputs: Changes according to the cost deflators shown above.

Simulation 3--World Efficient Steel Production

- Technology: coking, pelletizing, sintering → blast furnace → BOF → continuous cast → finish mill
- Process Improvements:
  1. $3.00/hr labor wages (1983 dollars), (1983 U.S. wages: $21/hr)
  2. $0.35/kcf natural gas prices (1983 dollars) (1983 U.S. gas: $3.50/kcf)
  3. 15 percent lower nongas fuel costs
- Cost of factor inputs: Changes according to the cost deflators shown above.

Simulation 4--U.S. Electric Furnace Production

- Technology: Scrap → electric arc furnace → continuous cast → finish mill
- No process improvements
- Cost of factor inputs: Changes according to the cost deflators shown above.

Figure 3-1 shows the results of these simulations over time. It can be seen that under the set of assumptions employed the cost disadvantage of the integrated process route cannot be overcome. By contrast, the cost of production by the electric furnace route is roughly similar to the costs of the most efficient world producers and becomes more competitive with time.

In addition to shipping and raw materials sourcing factors, Japanese producers have gained a materials cost advantage simply because they use less per ton of output. As discussed in Chapter 2, Japanese steel mills are, on average, much newer, larger, and

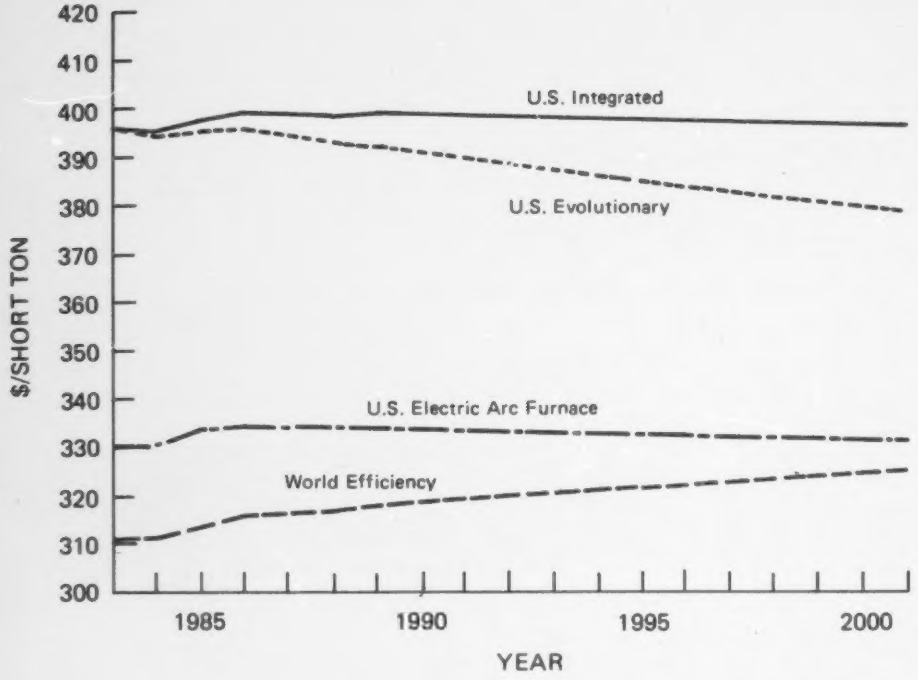


FIGURE 3-1 Steel Cost Simulations (Hot-Rolled Steel Sheet).

have better process control than U.S. mills. They also have a significantly higher percentage of continuous casting than the United States. The result is that the average yield, when processing raw steel into finished steel, is about 12 to 16 percent greater in Japan than in the United States.

The results of these cost simulations may be used to gain insights into two crucial issues: (1) the labor cost disadvantage to the United States, and (2) the technology disadvantage and potential for improvements.

The labor cost disadvantage has been well publicized. According to a recent Business Week article, labor costs at Pohang Iron and Steel Co. of South Korea are only $22 per ton, compared with $105 in Japan and $154 in the United States.[22] However, such estimates do not account for technology differences among the countries.

Table 3-18 shows the simulated cost of producing steel sheet for technologies 1, 2, and 5 at various levels of wage rates. It can be seen that the cost disadvantage associated with a labor cost of $22/hour is about $60 to $80/ton, compared with a labor cost of $2/hour, depending upon the technology.

TABLE 3-18 Cost of Steel Sheet as a Function of Labor Wages for Three Alternative Production Technologies

Wage ($/h)	Cost of Steel Sheet ($/ton) Technology 1	 Technology 2	 Technology 5
2	338	314	257
6	354	328	270
10	370	342	282
14	387	356	295
18	403	371	308
22	419	385	321
26	435	399	333

The impact of low labor wages on average steelmaking costs (over all five process routes) results in about a 17 percent cost reduction. Since bulk ocean freight rates for steel are small, low labor wages can be seen as a significant competitive advantage for those countries that can maintain them. This advantage may be partially offset by the employment of innovative and modern technologies in developed countries. However, as shown in simulations 1 through 4, it is unlikely that incremental technological improvements will significantly alter the competitive position of domestic integrated steel producers. It appears that a major technological innovation (such as direct strip casting, discussed in Chapter 2) will be needed to offset the labor and materials cost advantages of the United States' competitors.

NOTES

1. Trozzo (1982).
2. Ibid.
3. Crandall (1981).
4. American Iron and Steel Institute (August 1981).
5. Paine Webber Mitchell Hutchins (1981).
6. Highly leveraged firms, because of their large debt burdens, usually have relatively high fixed costs. In addition, many have large plants with large economies of scale in their operating costs. This is particularly true of the Japanese steelmakers, who--because of their high fixed costs and steeply declining cost-output curves--have relatively high average production costs at low operating rates and low average costs at high operating rates.
7. Paine Webber Mitchell Hutchins (1983).
8. Actually, the steel mills of the United Kingdom were higher-cost producers than those in the United States in 1981

because of a prolonged strike that lowered the actual operating rate.

9. Arthur D. Little, Inc. (1984).

10. Office of the Secretary, U.S. Department of Treasury (1978).

11. Trozzo (1982).

12. Ibid.

13. American Iron and Steel Institute (1980).

14. Crandall (1981).

15. Paine Webber Mitchell Hutchins (1981).

16. Arthur D. Little, Inc. (1978).

17. In exchange for a commitment from the domestic industry to reinvest the savings in steel facilities covered by the agreement, the United Steelworkers of America agreed, effective March 1, 1983, to (1) a reduction in wages of $1.25 per hour, (2) elimination of cost of living adjustments until August 1, 1984, and (3) reduction in certain benefits (reduction in Sunday premiums, elimination of one week of regular vacation in 1983 for employees entitled to at least two weeks, elimination of one holiday, and elimination of vacation bonus).

18. According to a Wall Street Transcript article (Charles A. Bradford, The Wall Street Transcript, April 4, 1983, pp. 69 & 324), in early 1983 total labor costs were $26 per hour in the United States, $12 per hour in both Japan and West Germany, and $15 per hour in Canada.

19. Arthur D. Little, Inc. (1977).

20. Magaziner and Reich (1983).

21. Charles Bradford, op. cit.

22. Business Week (1984).

4

Trends in the Production of Steel

UNITED STATES

In the 1950s and early 1960s the United States was unquestionably the leading steel producer in the world. In 1950 the U.S. industry produced almost half of the world's output. The Japanese industry, by contrast, was quite small, accounting for only about 3 percent of the world output in 1950. Since that year the U.S. producers' share of the world market has declined steadily (see Table 4-1), reaching a low in 1982. In terms of sustainable raw steel capacity, the U.S. industry is currently ranked third in the world, behind the Soviet Union and Japan, although the United States produced more tonnage than Japan in 1981 (see Table 4-2).[1] Over the past 20 years the domestic industry produced an average of about 120 million net tons of raw steel annually; 1973 was the industry's best year, when it produced in excess of 150 million net tons. From 1960 to 1974 raw steel production in the United States grew at an average annual rate of 3 percent but has been in decline since.

A pronounced shift has occurred over the past 20 years in the mix of steelmaking techniques utilized to produce carbon steel. Shown in Figure 4-1 are the percentages of carbon steel produced in the major types of steelmaking furnaces from 1960 to 1981. The significant trends are the final demise of the Bessemer process by 1966, the dramatic decrease of open-hearth (OH) steel production and corresponding rise in basic oxygen process (BOP) production, and finally the gradual rise of the electric furnace (EF) for the production of carbon steel. The open hearth was the dominant steelmaking process in 1960 (89.3 percent of the total carbon steel production). Since that time its high capital and operating costs compared with the oxygen and electric furnances have led to its decline in use. In 1981 its share of carbon steel production was only 12 percent. This trend is expected to continue. The commercialization of the oxygen steelmaking process

TABLE 4-1 World Production of Raw Steel, 1950-1982
(millions of net tons)

Year	United States	World	U.S. Percentage of World Production
1950	97	207	46.9
1951	105	232	45.3
1952	93	234	39.7
1953	112	259	43.2
1954	88	246	35.8
1955	117	298	39.3
1956	115	313	36.7
1957	113	322	35.1
1958	85	299	28.4
1959	93	337	27.6
1960	99	382	25.9
1961	98	390	25.1
1962	98	395	24.8
1963	109	422	25.8
1964	127	479	26.5
1965	131	503	26.0
1966	134	519	25.8
1967	127	548	23.2
1968	131	583	22.5
1969	141	632	22.3
1970	132	654	20.2
1971	121	633	19.1
1972	133	692	19.2
1973	151	767	19.7
1974	146	783	18.6
1975	117	712	16.4
1976	128	753	17.0
1977	125	742	16.9
1978	137	791	17.3
1979	136	824	16.5
1980	112	790	14.2
1981	121	781	15.5
1982	73	718	9.2

SOURCE: American Iron and Steel Institute, *Annual Statistical Report*, various issues.

in the mid-1950s and its adoption by the U.S. steel industry has resulted in a share increase from 3.7 percent of total carbon steel production in 1960 to about 65 percent in 1981. The workhorse of integrated plants, the oxygen furnace, will continue to be the major process for producing large tonnages of carbon steel in the foreseeable future. The gradual rise in the use of the electric furnace to produce carbon steel since the early 1960s has been the result of the emergence of the minimill segment of the industry. Production by the electric furnace increased more than fourfold from 1963 to 1979, going from 5.2 to 23.7 million net tons. Production of carbon steel by the electric furnace dropped slightly to

TABLE 4-2 Major Steel-Producing Countries, 1980-1981 (million metric tons crude steel production)[a]

	1981		1980	
	Rank	Tonnage	Rank	Tonnage
USSR	1	149.0	1	147.9
United States	2	108.8	3	101.5
Japan	3	101.7	2	111.4
West Germany	4	41.6	4	43.8
China	5	35.6	5	37.1
Italy	6	24.8	6	26.5
France	7	21.3	7	23.2
Poland	8	15.6	8	11.3
United Kingdom	9	15.6	15	11.3
Czechoslovakia	10	15.2	11	14.8
Canada	11	14.8	9	15.9
Romania	12	13.5	12	13.2
Brazil	13	13.2	10	15.3
Spain	14	12.9	13	12.6
Belgium	15	12.3	14	12.3
India	16	10.8	16	9.5
Republic of Korea	17	10.8	18	8.6
South Africa	18	8.9	17	9.1
Australia	19	7.6	19	7.6
Mexico	20	7.6	21	7.1
East Germany	21	7.5	20	7.3
Democratic Republic of Korea	22	5.5	22	5.8
Netherlands	23	5.5	22	5.8
Austria	24	4.7	24	4.6
Yugoslavia	25	4.0	29	3.6
Luxembourg	26	3.8	25	4.6
Sweden	27	3.8	26	4.2
Hungary	28	3.6	28	3.9
Taiwan	29	3.1	27	4.2
Bulgaria	30	2.6	31	2.6
Argentina	31	2.6	30	2.7
Turkey	32	2.4	32	2.5
Finland	33	2.4	33	2.5
Venezuela	34	2.0	34	1.8
Others	–	12.5	–	13.4
TOTAL	–	707.6	–	717.1

[a] All countries producing more than 2 million metric tons of crude steel in 1981.

SOURCE: International Iron and Steel Institute (1982).

22.5 million net tons in 1981, but its share of total production increased to greater than 23 percent.

As more open hearth capacity is closed in the future, new capacity may be built in the form of oxygen or electric furnace facilities. In the period 1960 to 1975 new oxygen and electric furnace capacity replaced open hearth capacity at the ratio of 3:1.[2] Recent trends have been in favor of the electric furnace, as shown in Table 4-3.

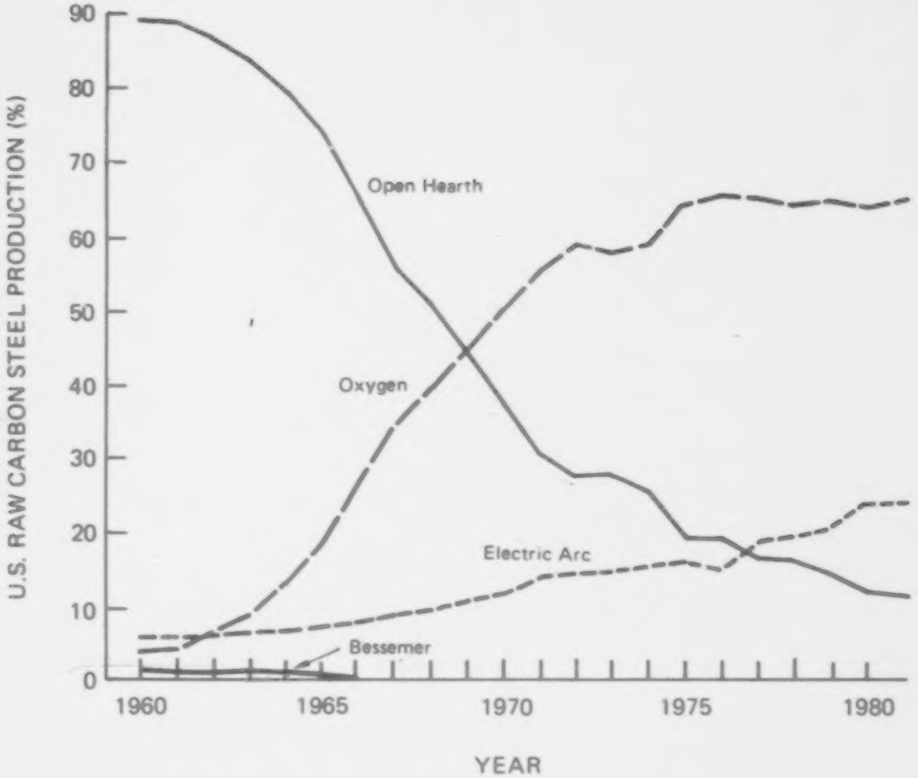


FIGURE 4-1 Percentage of Raw Carbon Steel Production by Furnace Type
SOURCE: American Iron and Steel Institute, Annual Statistical Report, various years.

TABLE 4-3 Steelmaking Capacity Expansion, 1975-1979

Start-up Year	Annual Estimated Raw Steel Capacity Addition (millions of net tons)	
	Electric Furnace[a]	Oxygen Furnace[b,c]
1975	1.845	–
1976	3.585	–
1977	0.550	–
1978	0.500	5.500
1979	2.690	–
TOTAL	9.170	5.500

[a] McManus (1980).
[b] *Iron and Steel Engineer*, annual review, various years.
[c] Pearce (1978).

It is generally agreed that the economic climate is not conducive to building new greenfield integrated steel facilities in the United States in the next decade. The investment that almost certainly will be made by the domestic steel industry in the near future will be for continuous casters. Such an investment offers an attractive return because of the approximately 10 percent improvement in yield (i.e., the ratio of finished steel shipments to the raw steel produced) that it offers, thus concurrently increasing effective capacity and productivity.[3] Table 4-4 shows recent data on continuous casting production and capacity in developed countries. The U.S. industry has obviously lagged behind the other developed countries in the installation of continuous casters; by the late 1980s it is expected that the U.S. industry will be able to continuously cast about half of its output. It is possible that replacement and modernization capacity, other than continuous casters, will be built during the 1980s (as discussed in Chapter 8). However, the major additions to capacity are expected from the electric furnace/minimill sector.

There are essentially three reasons for the apparent comparative advantage of the minimill sector: lower capital costs, lower operating costs, and lower marketing expenses. The average capital cost of an electric furnace producing a homogenous

TABLE 4-4 Continuous Casting (C.C.) Capacity and Production in Selected Countries, 1977-1982 (millions of metric tons)

	1977	1978	1979	1980	1981	1982
United States						
C.C. capacity	23.92	25.17	25.87	27.02	28.94	31.99
C.C. production	13.43	17.60	20.46	19.69	23.07	18.60
% Production by C.C.	11.80	14.20	16.60	19.60	21.40	28.30
Japan						
C.C. capacity	56.05	57.57	60.79	68.10	77.57	82.49
C.C. production	41.80	47.16	58.12	66.27	71.84	77.65
% Production by C.C.	40.80	46.20	52.00	59.60	70.60	78.70
West Germany						
C.C. capacity	NA	NA	NA	NA	NA	NA
C.C. production	13.27	15.67	17.95	20.16	22.32	24.40
% Production by C.C.	34.00	38.00	39.00	46.00	53.60	57.10
TOTAL C.C.						
C.C. capacity	48.56	54.97	58.96	70.82	79.74	85.45
C.C. production	32.04	38.32	43.40	49.92	56.58	62.10
% Production by C.C.	25.40	28.90	31.00	39.30	45.10	57.50

NA, not applicable.

SOURCE: Merrill Lynch, Pierce, Fenner and Smith, Inc. (1982); Paine Webber Mitchell Hutchins, Inc. (1983).

product line is estimated to be in the range of $150 to $300 per annual ton (1981 dollars) of capacity. This may be compared to a recent estimate of $1,130 per ton for replacement cost in the integrated steel industry made by the Tripartite Committee.[4] The majority of the difference in capital requirements may be attributed to the fact that electric furnace production does not require investments in coke ovens and blast furnaces and, as minimills typically produce a limited range of products, investment in finishing facilities is also relatively small.

Operating costs, in the form of labor, raw material, and energy, are typically lower for the minimill sector compared with integrated mills. Part of this difference is due to the fact that most minimills usually make simple, nonflat products and can therefore use continuous casting for all their output, so that a large relative increase in yield may be attained. The yield for integrated steel production is currently around 73 to 74 percent for the domestic steel industry as a whole, but is about 87 percent for the minimill sector. The greater processing efficiency, coupled with the use of nonunion labor,[5] has increased the output per man-hour of the minimills dramatically. It takes about 1,700 production employees to produce a million tons of finished steel in the electric furnace sector compared to about 3,000 employees per million tons for the older integrated facilities. Employment costs are also relatively low because the work force is relatively young, thereby providing for lower wage costs, benefits, and pension liabilities. Further, because electric furnaces use essentially 100 percent scrap as the raw material charge, they consume less energy per ton of product than do integrated processes and in the past have paid less for their raw materials, on average.

Marketing expenses are lower for the minimill segment because of its concentration on a limited line of products and local markets. Further, because the minimills serve local markets, transportation costs are usually small. Despite the optimism over the future of electric furnace production in this country,[6] there is some concern about the potential for the growth of electric furnaces because of three factors:[7] (1) the size of the market that can be satisfied by typical electric furnace mills; (2) the price and availability of scrap, or imported or coal-based direct-reduced iron (DR); and (3) the effects of the maturation process on the economics of production.

Projections of electric furnace production for the period 1982 to 1990 are shown in Table 4-5. It is generally agreed that in the period 1982 to the late 1980s there is sufficient scrap resource availability to expand the electric furnace sector by 8 to 12 million tons of annual raw steel capacity, as shown.

TABLE 4-5 Projections of Capacity Expansion by Electric Furnaces in the United States (millions of net tons)

Year	Raw Steel Capacity	Finished Steel Capacity
1982	0	0
1983	2	1.7
1984	4	3.5
1985	6	5.2
1986	8	7.0
1987	10	8.7
1988	12	10.4
1989	14	12.2
1990	16	13.9

NOTE: It is assumed that new electric furnace capacity will be accompanied by continuous casting capability and that the yield of finished steel from raw steel will be 87 percent.

DEVELOPING COUNTRIES

According to reports published in the past few years, developing countries will account for the preponderance of new steelmaking capacity in the noncommunist world through the remainder of the decade.[8-11] The growth of capacity in the developing world, coupled with stagnant or declining capacity in the industrialized market economies, will have major implications for U.S. producers.

Not only will the U.S. share of the total world market continue to shrink, but the percentage of total capacity at least partially owned or controlled by national governments will increase. Thus, it will be increasingly difficult for U.S. producers to compete for export sales in the world market. However, a more significant problem for domestic producers will be the increased pressure placed on the competition for the U.S. market. The growth in capacity and self-sufficiency of developing countries will reduce the size of that export market and increase the pressure to export steel to the United States by both industrialized and developing countries in order to improve depressed operating rates.

Tables 4-6 and 4-7 show estimates by the U.S. Central Intelligence Agency (CIA) and the United Nations International Development Organization (UNIDO) of carbon steel capacity in developing countries for various years between 1978 and 1990. In 1975 the capacity of developing world countries was about 40 million metric tons. At that time developing countries had announced plans to expand production capacity to about 175 million metric tons by 1985. However, the international recession of 1975 and 1976 and the ensuing weak market conditions and rising costs have forced many of these producers to abandon or delay completion schedules.

TABLE 4-6 CIA Estimates of Raw Steelmaking Capacity in Developing Countries, by Year (millions of metric tons)

	1978	1980	1985
Latin America	30.5	36.5	56.0
Brazil	14.0	15.0	25.0
Mexico	9.0	10.0	13.5
Venezuela	1.5	4.0	6.5
Argentina	4.0	5.0	7.0
Others	2.0	2.5	4.0
Africa	1.7	3.0	7.0
Algeria	0.6	1.0	2.0
Others	1.1	2.0	5.0
Middle East	4.6	4.7	7.2
Iran	2.0	2.0	2.0
Egypt	1.8	1.8	2.2
Saudi Arabia	–	–	1.6
Others	0.8	0.9	1.4
Asia	27.2	31.7	41.8
India	13.5	14.3	19.0
South Korea	7.3	8.0	10.5
Taiwan	4.0	5.0	7.0
Indonesia	1.0	2.0	2.0
Others	1.4	2.4	3.3
TOTAL	64.0	75.9	112.0

SOURCE: CIA (1979).

The problem for developing countries is that financing for capacity expansion must be provided mainly by government grants or loans, and the availability of capital from internal sources has been strained by balance of payments problems. External sources of funds--from private domestic or international lending institutions or from major steel producers in developed countries--are not likely to be plentiful as long as the world steel market is experiencing excess capacity problems.

TABLE 4-7 UNIDO Estimates of Steel Production Capacity in Developing Countries (millions of metric tons)

	1980	1990	
		Low Growth	High Growth
Africa, South of the Sahara	1.25	4.52	10.45
North Africa and the Middle East	5.75	15.44	25.05
Latin America	35.00	63.12	81.90
Asia	34.00	56.40	75.50
TOTAL	76.00	139.48	192.90

SOURCE: United Nations International Development Organization (UNIDO), 1982 UNIDO Steel Industry Conference Report (Caracas).

By early 1977 plans for total capacity in developing countries in 1985 had been curtailed to 140 million metric tons. The estimate by the CIA of 112 million metric tons in 1985 is probably in a more realistic range because it reflects the continuing recession in the world steel market as well as escalating installation costs. A similar estimate of 114 million metric tons for the developing countries in 1985 was recently made by the Organization for Economic Cooperation and Development (OECD).[12]

Although the CIA and OECD estimates are significantly less than the announced expansion plans of developing countries, these figures (i.e., 112 to 114 million metric tons) represent a substantial growth in capacity for this sector. For example, if accurate, these forecasts would mean that the developing countries will have approximately tripled their capacity over the period from 1975 to 1985, increasing their share of the world market to about 17 percent in 1985.

Estimates of developing world capacity in 1990 made by UNIDO are shown in Table 4-7. Actually, two scenarios were created: one assuming that the world experiences a low rate of economic growth in the future, and the other assuming a high growth rate. In the UNIDO low growth rate scenario, it is assumed that the trends of the period 1977 to 1981 will continue to operate until at least 1990. Under this scenario the mean annual rates of growth of the gross domestic product (GDP) are:

Developed market economy countries	2.4
Communist countries of Eastern Europe	3.5
Developing countries	4.2

The financial constraints and the relatively low level of world steel consumption that result from a low growth rate scenario lead to the likelihood that only those projects that are already under construction or have firm financial support will actually result in the installation of new production capacity. There are 75 projects that belong to such a classification, with an annual production capacity of about 63.5 million metric tons. These are distributed as follows:

Africa, south of the Sahara	3.3	(7 projects in 3 countries)
North Africa and the Middle East	9.7	(10 projects in 7 countries)
Latin America	28.1	(34 projects in 12 countries)
Asia	22.4	(24 projects in 11 countries)
TOTAL	63.5	

The second UNIDO scenario, called the normative scenario, is one of high economic growth (in this report, "high growth scenario"). It results in the installation of production capacity corresponding to the amount announced by developing countries.

Under this scenario, in addition to those projects outlined in the low growth scenario, it is assumed that those projects now being negotiated and/or that are under feasibility study will be completed by 1990. If such a course of events is realized, the result would be an additional capacity of 117 million metric tons in 1990. The new capacity in millions of annual metric tons would be distributed as follows:

Africa, south of the Sahara	9.2 (32 projects)
North Africa and the Middle East	19.3 (26 projects)
Latin America	46.9 (42 projects)
Asia	41.5 (38 projects)
TOTAL	116.9

Participants at the 1982 UNIDO Steel Conference in Caracas felt that for such a scenario to occur the following annual percentages (rates) of growth would be needed:

	Gross Domestic Product	Manufacturing Value Added
Developed countries	3.5	4.4
Developing countries	6.3	6.9
World	4.0	4.6

INTERNATIONAL TRENDS

Estimates of raw steel capacity in the various geographical and political sectors of the world from two recent reports are shown in Table 4-8. Sustainable capacity is defined as that amount of production that can be achieved on average over an entire year under normal operating conditions. However, it is an imprecise measure because it neglects the effects of price fluctuations, technical innovations, and unforeseen exogenous influences.

The implications of the trends in production capacity are rather ominous and were discussed in the previous section of this chapter. From the numbers reported in Table 4-8, the market share of the industrialized countries (the United States, Japan, the EEC, and other industrialized countries) as a percentage of total sustainable capacity can be calculated; the market share of the industrialized countries declines from 62 to about 52 percent of the total over the period 1978 to 1990; the market share of the United States declines from 16 to 13 percent of the total over the same period. Moreover, current trends are toward an increasing percentage of government control or participation in the steel-

TABLE 4-8 Estimates of Sustainable Raw Steel Production Capacity (millions of metric tons)

	1978		1980		1985		1990	
	WSD[a]	Mueller[b]	WSD	Mueller	WSD	Mueller	WSD	Mueller
United States	132	136	128	131	124	126	122	124
Japan	137	137	138	136	137	136	139	138
EEC	166	173	164	170	151	158	141	145
Other industrialized countries	66	67	66	72	69	78	74	86
Developing countries	61	55	67	66	98	88	118	102
Centrally planned economies	250	257	266	275	297	305	324	335
TOTAL	812	825	829	850	876	891	918	930

NOTE: WSD includes South Africa in the estimates for developing countries. Mueller includes South Africa in the category of other industrialized countries.

[a] WSD = Paine Webber Mitchell Hutchins, Inc. (1983).

[b] Mueller (1982).

SOURCE: UNIDO.

making operations of industrialized countries (e.g., France, the United Kingdom, and Belgium).

NOTES

1. International Iron and Steel Institute (various years).

2. Clark, Elliot, Tribendis, and Baldwin (1982).

3. It should be pointed out that it is only possible to increase capacity by the adoption of continuous casting if bottlenecks do not exist at the finishing end of the steelmaking sequence. If bottlenecks do exist, it would also be necessary to increase capacity of the finishing mills to effect an overall increase in steelmaking capability.

4. Tripartite Advisory Committee Report to the President (1980). This estimate includes expenditures for sources of iron ore and coking coal.

5. Approximately 50 percent of the labor force of the minimills is unionized.

6. Robert R. Nathan Associates, Inc. (1979).

7. Clark, Elliot, Tribendis, and Baldwin (1982).

8. U.S. Central Intelligence Agency (1979).

9. Mueller (1980a).

10. United Nations International Development Organization (1982).

11. Organization for Economic Cooperation and Development (1982).

12. Ibid.

5

Markets for Steel Products

An appreciation of the elements that determine the demand for steel in both the United States and the world market is important because of the necessity for projecting national and international supply/demand balances and for understanding the implications of alternative forecasts on the competitive position of the domestic industry. This chapter briefly reviews the important components and determinants of steel consumption and historical trends in steel demand and presents conditional forecasts of apparent steel consumption for the years 1985, 1990, and 2000.

There are two important characteristics of the demand for steel products in mature economies such as those of the United States, western Europe, and Japan. First, the demand for steel grows at a significantly slower rate than that of the overall economy. In the United States the long-term growth rate varies depending upon the time period used for the calculation, but in the past 30 years this rate has been roughly 1.0 percent annually. In the past 10 years consumption has been on a slightly negative trend. Although growth rates in western Europe and Japan were significantly higher than this during the rebuilding years following the Second World War, in the past 10 years steel consumption trends in these two regions have been similar to those in the United States.

Second, although the overall pattern of steel consumption in developed countries is stagnant, there are significant cyclic fluctuations around this trend. This should not be surprising when we consider that approximately 75 percent of total steel consumption in the United States is the result of public and private capital investment (including local). Figure 5-1 shows the historical variation in domestic steel consumption over the period 1946-1982. There have been two cycles in steel consumption during this period, of roughly 16 years each. The first is from 1946 to about 1962 (the cycle is greater if the data for the strike years of 1958 and 1959 are smoothed); the second, from approximately 1963 to

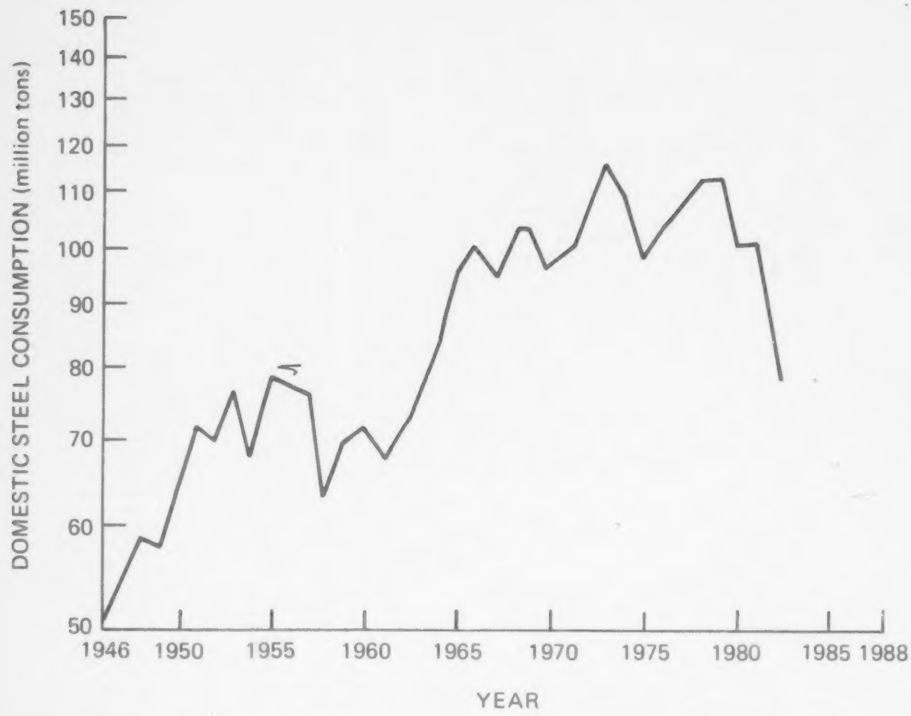


FIGURE 5-1 Historical Domestic Steel Consumption in the United States
SOURCE: U.S. Steel Corporation, Market Research.

1979. From Figure 5-2 we can see reasonably clearly the relationship between steel consumption and real capital investment expenditures. The correlation is even greater when we exclude the data for shipments to the automotive sector--which are erratic and not directly dependent on capital investment expenditures on an annual basis--as we can see from Figure 5-3.

Table 5-1 illustrates how domestic consumption of carbon steel has been distributed among the important consuming sectors in the recent past. During this time period the total apparent consumption of all grades of finished steel products--carbon, alloy, and stainless--varied from a high of about 124 million net tons in 1973 and 1974 to a low of about 76 million net tons in 1982.

A detailed analysis of the sectoral demand for carbon steel products is beyond the scope of this study. However, a discussion of historical consumption trends and an analysis of technical factors related to materials usage and substitution in each of the end use sectors has been published in a recent report to the U.S. Bureau of Mines.[1] The report includes an econometric model of

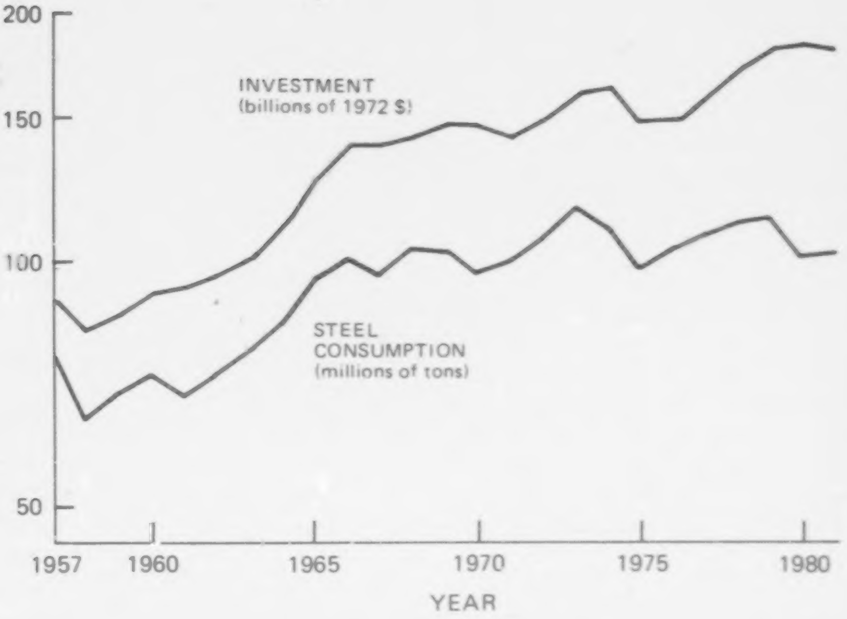


FIGURE 5-2 Real Investment Expenditures and Steel Consumption in the United States
SOURCE: U.S. Steel Corporation, Market Research, unpublished data.

the demand for finished steel products in the United States. The model consists of regression estimates of demand in eight end use sectors and 13 shape groups. Some of the conclusions of the study that are of interest here are as follows:[2]

- The prices of substitute materials (which include plastics and certain aluminum shapes and alloys, depending on category) are significant explanatory variables of steel consumption in only a few cases. For instance, the price of plastics was found to be significant as an explanatory variable for pipe and tubing in the motor vehicle and consumer durables sectors. However, in greater than 95 percent of the equations it was found that the consumption of carbon steel is not sensitive to the prices of substitute materials at the relative prices that existed in the past. Technical change, however, was found to be an important determinant of consumption shifts, especially in the automotive industry and in a few other sectors.
- Total consumption of carbon steel (domestic shipments plus imports) is relatively insensitive to the average price, at least in the range of historical (1963-1978) interest. In general, the

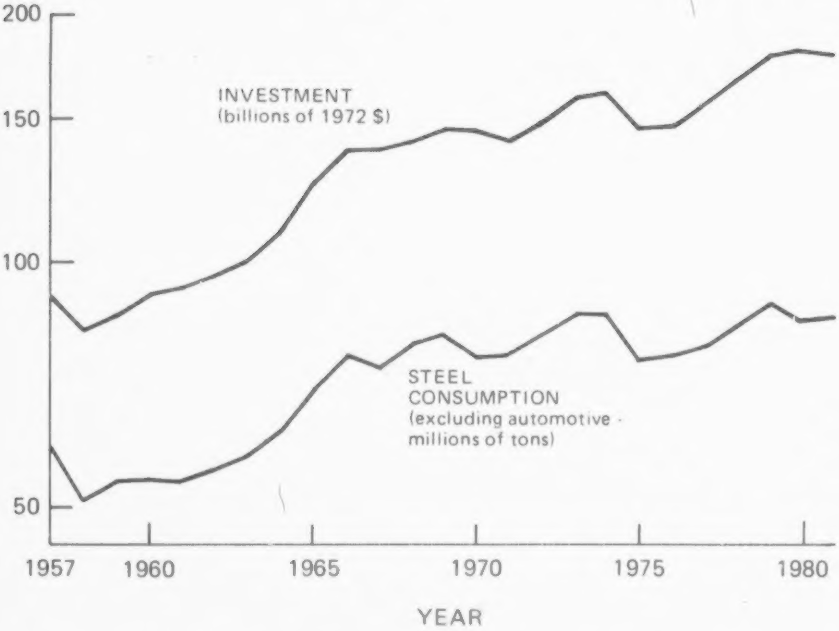


FIGURE 5-3 Real Investment Expenditures and Steel Consumption (Net Automotive Shipments) In the United States
SOURCE: U.S. Steel Corporation, Market Research, unpublished data.

demand for steel is price-inelastic in those uses where a shape is used in large tonnages. Examples include hot-rolled bars (E_p = -0.07) and hot- and cold-rolled sheet and strip in motor vehicles (E_p = -0.44 and -0.28, respectively), structurals (E_p = -0.73), hot-rolled bars (E_p = -0.47) and plates (E_p = -0.19) in construction, and tin mill products (-0.70) in containers and packaging. A value of E_p = -0.70 means that if the price increases by 10 percent, we could expect consumption to decrease by about 7 percent if other factors (such as industrial activity) do not change.

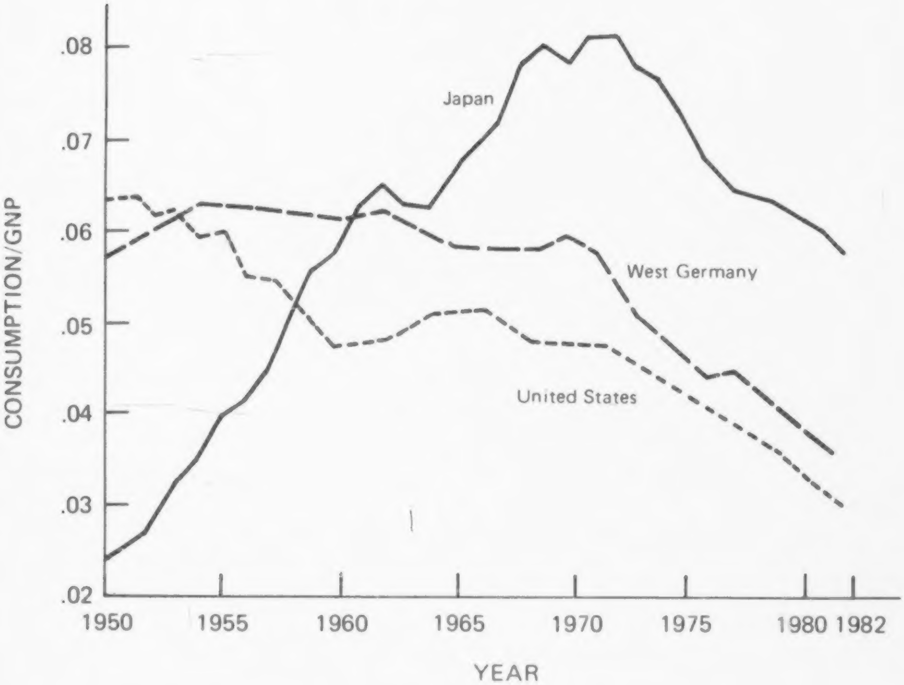
- The demand for high-priced products, such as cold finished bars and tin mill products (in all sectors other than packaging), is a function of the price. In each of these cases the price elasticity of demand was greater than -1.0.
- The demand for carbon steel is essentially unit-elastic with respect to industrial activity when averaged across all products and end uses. Although there is some fluctuation across the shape groups and end-use sectors, a 1 percent change in the economic activity of a particular industrial sector would also result in a 1 percent change in carbon steel consumption in most of the major tonnage categories.

TABLE 5-1 Apparent Consumption of Carbon Steel Products in the United States by End Use, 1970-1982

Year	Motor Vehicles	Construction	Consumer Durables	Producer Durables	Rail Transportation	Containers and Packaging	Oil and Gas Industry	Other	Total
1970	19.5	22.9	5.6	11.6	3.4	9.0	1.4	16.8	90.3
1971	23.8	22.7	5.7	11.5	3.4	8.4	1.6	17.7	94.8
1972	24.9	22.3	6.1	12.7	3.1	8.0	1.7	18.7	97.4
1973	29.8	26.4	6.5	14.3	3.4	9.2	2.3	20.9	112.8
1974	24.6	27.7	6.1	14.6	3.8	9.6	2.8	20.9	110.0
1975	19.3	18.3	4.1	10.8	3.3	7.0	3.0	14.8	80.7
1976	26.8	19.0	5.1	12.2	3.2	8.0	2.0	16.0	92.3
1977	28.5	20.1	5.7	12.9	3.6	8.0	3.0	16.8	98.6
1978	27.7	22.5	5.7	14.2	3.7	7.9	3.2	20.3	105.4
1979	22.0	23.0	5.8	14.2	4.3	8.0	3.0	21.9	102.2
1980	14.5	18.9	4.5	11.7	3.3	6.7	4.1	21.4	85.1
1981	15.8	19.2	4.8	12.2	3.2	6.5	5.1	24.9	91.7
1982	10.6	14.7	4.0	8.4	3.0	5.1	3.1	20.7	69.6

NOTE: These data were constructed by aggregating various AISI categories and by allocating shipments to service centers and imports to the end-use sectors by a method described in Tribendis (1981).

SOURCE: American Iron and Steel Institute, *Annual Statistical Report*, various years.



SOURCE: Barnett and Schorsch (1983).

FIGURE 5-4 The Steel Consumption/GNP Ratio Over Time in Some Developed Countries
SOURCE: Barnett and Schorsch (1983).

As previously stated, the two most important factors that describe the behavior of aggregate steel consumption over time in developed countries are: (1) declining intensity of use and (2) capital investment expenditures. The first of these factors is shown clearly in Figure 5-4, which depicts the relationship between steel consumption and gross national product (GNP) in the United States, Japan, and West Germany. Although there are fluctuations in the ratio of steel consumption/GNP over time, and the United States shows the strongest and earliest trends, all three countries exhibited obvious declines in intensity of use in the 1970s.

There are four fundamental reasons for the long-term decline in the steel intensity of use. First, as economies mature, the percentage of economic output represented by the manufacturing sectors diminishes relative to the service-oriented sectors. This phenomenon is partly due to decreased needs for steel-intensive investments in infrastructure (e.g., manufacturing plants, heavy equipment, roads, bridges, railroads) as industrial development becomes advanced, and partly due to changes in consumer preferences that come with increased affluence.

Second, changes in manufacturing methods and equipment as technology becomes more sophisticated lead to a relative decrease in steel consumption. For example, electronic manufacturing processes are significantly less steel-intensive than traditional mechanical methods. Moreover, computer-controlled machine tools are more efficient than their manually controlled counterparts, thus increasing the output per unit of steel contained in the product.

Third, the efficiency of use of steel in manufactured goods has improved with time, reflecting changes in product design as well as improvements in product technology. For example, downsizing of automobiles by U.S. manufacturers led to a decrease in carbon steel consumption by that industry of more than 25 percent over the period 1971-1981 (see Table 5-1). Developments in casting and container technology have led to dramatic reductions in the wall thickness of engine blocks and the gauge of metal sheet used in beverage cans, respectively.

Fourth, carbon steels have experienced increasing competition from other materials, a problem that is likely to intensify with time. Aluminum now dominates in beverage cans, with greater than 85 percent of the market in 1983. Moreover, there is concern among some steel producers that aluminum cans and plastic pouches will become formidable competitors in the market for food cans in the near future.

In the automotive market, polymeric materials have made substantial inroads, particularly in parts where weight, corrosion resistance, formability, and consolidation are important. High-strength steels have been developed, some with excellent formability with the newer materials in the near term. However, even these materials, such as high-strength, low-alloy steels and dual phase steels, could be considered to compete with traditional carbon steel because their use will reduce total steel tonnage requirements on a per product basis.

In order to quantify the relationship between the demand for steel products and growth in the economy of the United States, ordinary least squares regression equations were estimated based on annual data over the period 1954-1982. A number of equations of the generic type steel consumption = f (time, economic activity) were investigated. The statistical results of each of the estimations were similar, and the precise functional form was found to be unimportant. Each of the estimations contained a time factor to account for the gradual decrease in the steel intensity of use. One of the estimated equations is shown below. The t- statistics are in parentheses below the coefficients.

$$\ln (Q/IPI) = 7.44 - 2.12 \ln T + 0.286 \ln GPDI$$

Q = steel demand in the United States (millions of net tons) AISI shipments + imports - exports - change in user inventory
T = time factor (54, 55, ..., 81)
IPI = industrial production index (1976 = 100)
GPDI = gross private domestic investment (billions of 1972 dollars)

It is important to note that according to this equation, rates of growth in the domestic economy (as measured by the industrial production index) of less than about 2 percent per annum lead to a declining rate of steel consumption, a result that is in agreement with the judgmental analyses of two recent reports.[3,4]

PROJECTIONS OF DOMESTIC STEEL CONSUMPTION

Projections of future steel consumption in the United States are as uncertain as the outlook for the aggregate economy. This is not surprising, of course, since the consumption of steel is so closely correlated with the level of industrial production.

TABLE 5-2 Conditional Forecasts of Apparent Steel Consumption in the United States Based on the Industrial Production Index and Gross Private Domestic Investment

		U.S. Industrial Production Index (1967 = 100)	Gross Private Domestic Investment (billions of $ 1972)	Apparent Domestic Steel Consumption (millions of net tons of finished steel products)
1980		147.0	208.4	95.2
1981		151.0	225.8	105.4
1982		138.6	196.9	76.4
Average 1980-1982		145.5	210.4	92.4
1985	Low	149.9	210.4	96.5
	Medium	156.7	223.2	102.6
	High	163.7	233.3	108.6
1990	Low	157.6	210.4	92.8
	Medium	177.3	246.5	109.2
	High	199.1	277.1	126.8
2000	Low	174.0	210.4	79.0
	Medium	226.9	300.5	114.0
	High	294.8	390.8	160.2

Although a surge in expenditures for industrial investment projects could precipitate a surge in steel consumption at some point in the future, it appears that manufacturing activity will not be high enough, on average, to force domestic consumption to levels beyond those of the recent past.

With due regard to the considerable uncertainty associated with prophesies of the future, three scenarios were constructed: low (pessimistic), medium (moderate growth), and high (optimistic). Each of the scenarios depends upon assumptions about growth rates of the aggregate domestic economy (represented by the industrial production index) and real gross private domestic investment. The regression equation reported in the previous section of this report was used to project future consumption. The low-growth scenario assumes that the U.S. industrial production index (IPI) will grow at an annual rate of only 1 percent, while gross private domestic investment (GPDI) will not experience any future growth for IPI and 2 percent for GPDI. The high-growth scenario assumes 4 percent growth for IPI and 3.5 percent for GPDI. The growth rates were applied to the averages of the 1980, 1981, and 1982 values of these variables. Table 5-2 shows the 3-year averages for IPI, GPDI, and apparent domestic finished steel consumption, as well as projected consumption values under the three scenarios. If the economy expands according to the optimistic assumptions, steel consumption should be in the 125 to 130 million annual ton range by 1990. However, if the pessimistic assumptions about economic growth prevail, steel consumption would remain stagnant over the remainder of the decade and actually experience a significant decrease in the longer term, primarily because of a declining intensity of use. The forecasts for the year 2000 exhibit a considerable range between low and high values, reflecting the increasing uncertainties with time concerning future economic growth and the mix of national output.

Although we are far from confident about our forecasts, it is somewhat comforting that recent publications have presented estimates that are not dissimilar to those of Table 5-2. Shown in Table 5-3 are comparative finished steel forecasts of this and four other studies. The projections for 1985 of four of the studies are in close agreement. The U.S. Department of Commerce (DOC)[5] estimate, although higher than the others, was actually presented as a range, from 110 to 128 million annual net tons. In the DOC study it was assumed that finished steel demand would likely grow at an annual rate of about 1.3 percent over the period 1980-1985, relative to the 1978-1980 average of 110 million net tons. It should also be pointed out that the DOC study (published in July 1982), preceeded the other four studies.

TABLE 5-3 Comparative Recent Forecasts of Apparent Domestic Finished Steel Consumption (millions of net tons of steel products)

Year	WSD[a]	Barnett and Schorsch (1983)	Merrill Lynch	DOC[b]	Medium[c]
1985	103	103	98	119	103
1990	114	107	99	–	109
2000	–	117	109	–	114

[a] Paine Webber Mitchell Hutchins, Inc. (1983).
[b] U.S. Department of Commerce (1982).
[c] Medium economic growth scenario of Table 5-2.

FORECASTS OF WORLD STEEL CONSUMPTION

It is useful to project world steel consumption for the remainder of the decade and to compare these figures with the projected numbers for world capacity in order to assess the future world supply-demand balance and the implications for the competitive position of U.S. producers. The fact that, in the aggregate, carbon steel consumption is insensitive to the average price (at least in the range of interest) allows one to make reasonable estimates of future consumption without accounting for supply-demand-price interactions. Similarly, production and capacity planning decisions of a number of developing countries appear to be based more upon a desire to attain self-sufficiency than on the export market for steel.

Historical statistics are shown for the important consuming groups of the world in Table 5-4. All figures are reported in terms of millions of metric tons of raw steel equivalent because in many countries finished steel shipments are not reported and consumption must be deduced from production, imports, and exports data.[6] In order to provide consistency, the data for finished steel shipments in the United States are transformed to raw steel equivalent. Starting with shipments data, the implied value of raw steel production is calculated by dividing by the expected yield (of raw steel to finished steel) at that time. Raw steel production is then adjusted by any expected change in mill stocks (assuming an 80 percent yield of semifinished to finished steel) and net imports are added after converting from finished steel to raw steel equivalent. Historical consumption trends and the forecasts are discussed below for each region.

Japan

Apparent steel consumption in Japan grew at a rate greater than 12 percent per year over the period 1950-1976. Even

TABLE 5-4 World Steel Consumption: Historical Data (millions of metric tons of raw steel equivalent)

	1960	1970	1978	1979	1980	1981	1982
United States	91	127	145	143	118	128	88
Japan	19	70	67	79	79	72	79
European Economic Community	82	124	102	115	109	101	101
Other industrialized countries[a]	30	55	56	60	61	61	58
Developing countries[b]	14	38	91	95	99	98	102
Total market economics	236	414	451	492	466	460	428
Planned economies	107	176	260	260	256	250	255
TOTAL	344	590	711	752	722	710	683

[a] Other industrialized countries include other Western European countries (i.e., other than EEC countries) and Canada, South Africa, Australia, and New Zealand.

[b] Developing countries include Latin America; Africa, except South Africa; the Middle East; and Asia, except Japan, China, and North Korea.

SOURCES: 1960-1981–International Iron and Steel Institute (1982); 1982–Organization for Economic Cooperation and Development (1983).

though the rate of growth in consumption declined to about 9 percent per annum over the period 1960-1976, steel consumption per unit of GNP was still greater than the rate of growth of GNP per capita. Since 1967 apparent steel consumption in Japan has grown by only 3.1 percent, compared with less than 1 percent in the United States over this same period, and it is likely that this rate of growth will not increase in the future. Actually, as in all other industrialized countries, consumption has not yet recovered to the peak level of 1974. It is particularly difficult to determine exactly what the underlying demand for steel will be in Japan in the future, since a substantial part of Japanese domestic steel consumption depends on exports of products containing steel, such as the automotive and consumer durables sectors. The export markets for these products are obviously dependent upon the vagaries of world trade policies, which are at best difficult to predict.

Our forecast for apparent steel consumption in Japan is for 83 million metric tons in 1985, remaining essentially flat for the remainder of the century. These numbers may be compared with those of other recent reports noted in Table 5-5.

European Economic Community (EEC)

The rate of growth of apparent steel consumption in the nine countries of the EEC was 4.3 percent annually from 1950 to 1975,

TABLE 5-5 Comparisons of Forecasts of World Steel Consumption by Country Group (millions of metric tons of raw steel equivalent)

	1985	1990	2000
United States			
NRC[a]	121	121	118
Mueller (1982)	133	137	143
Barnett and Schorsch (1983)	122	129	136
Japan			
NRC[a]	80	80	80
Mueller (1982)	80	85	95
Barnett and Schorsch (1983)	91	91	91
EEC			
NRC[a]	105	105	105
Mueller (1982)	111	114	119
Barnett and Schorsch (1983)	123	125	136
Other Industrialized Countries			
NRC[a]	60	65	70
Mueller (1982)	64	68	75
Barnett and Schorsch (1983)	27	30	45
Developing Countries			
NRC[a]	128	163	241
Mueller (1982)	113	131	176
Barnett and Schorsch (1983)	136	164	205
Total Market Economies			
NRC[a]	494	534	614
Mueller (1982)	501	535	608
Barnett and Schorsch (1983)	499	539	613
Planned Economies			
NRC[a]	265	270	285
Mueller (1982)	262	269	282
Barnett and Schorsch (1983)	260	260	277
TOTAL			
NRC[a]	759	804	899
Mueller (1982)	763	804	890
Barnett and Schorsch (1983)	759	799	890

[a] Estimate of members of the Steel Panel.

which was essentially the same as the annual rate of growth in the aggregate GNP of the individual countries. Since 1960 apparent steel consumption has grown at a rate of about 3 percent annually. Moreover, since 1969 (excluding the outlying data points for the years 1973 and 1975), apparent steel consumption in the EEC has declined slightly over time. The forecast for apparent steel consumption in the EEC in 1985 is for a total of 105 million tons of raw steel (equivalent). It is expected that the trend in raw steel (equivalent) by the EEC will remain flat for the remainder of the century because of declining intensity of use and increase in yield. These numbers are somewhat lower than those forecast by both Mueller[7] and Barnett and Schorsch.[8]

Other Industrialized Countries

The other industrialized countries--which include the western European countries that do not belong to the EEC, Canada, Australia, and New Zealand--have experienced similar growth patterns to those of the United States and the EEC. Consumption during the decade of the 1970s has been stagnant. Forecasts of slightly increased consumption in the future reflect an assumption that the aggregate real growth rate of the economies will be moderately greater than 2 percent per annum over the next decade. The differences between the National Research Council (NRC) forecasts and those of Barnett and Schorsch[5] reflect a different grouping of "other industrialized world" and "developing world" countries.

Developing Countries

Demand patterns for steel in the developing countries of the world exhibit higher growth rates than the developed countries, reflecting the correlation between steel consumption and industrial growth and a higher intensity of steel use in the developing economies. Since 1970 apparent steel consumption in the rest of the developing countries has grown at about 8.5 percent annually, if the years 1971 and 1974 are smoothed by interpolation. Since 1974-1975 growth has slowed to about 6.0 percent per annum, and in a number of countries growth has been considerably slower. Despite continuing balance of payments problems, it is expected that construction and motor vehicle use in developing countries will continue to be strong during the 1980s. However, total consumption is expected to grow at somewhat less than the historical rate. The assumption of a 5 percent annual rate of growth from a base of 100 million metric tons (raw steel equivalent) in 1980 results in consumption figures of about 128 and 163 million metric tons in 1985 and 1990, respectively. Assuming a slightly lower annual rate of growth of 4 percent in the 1990s results in a consumption estimate of about 241 million annual metric tons in the year 2000.

NOTES

1. Clark, Elliot, Tribendis, and Baldwin (1982).
2. Ibid; also Tribendis (1981).
3. Barnett and Schorsch (1983).
4. U.S. Department of Commerce (1982).
5. Ibid.

6. There is a problem with reporting steel consumption in terms of raw steel equivalent, however. Although the yield--i.e., the conversion factor of raw steel to finished steel products--was relatively constant on an international basis until about 1973-1975, it has begun to creep upward as the use of continuous casting has increased. Therefore, the usefulness of raw steel equivalent as a common denominator has decreased in value.

7. Mueller (1981).

8. Barnett and Schorsch (1983).

9. Ibid.

6

Imports in the Domestic Market

HISTORICAL TRENDS

The annual tonnage of imported steel products has increased nearly fourfold over the past 15 years. Total imports increased from about 6 to 20 million net tons from 1963 to 1981, respectively. The 1978 value of 21.1 million net tons represents the highest annual tonnage ever in the United States. Although the absolute tonnage level of imports declined to 16.7 million net tons in 1982, imports as a fraction of total apparent consumption reached a historical high, at about 24 percent.

Although quantities of imported steel have fluctuated over time, since 1965, when the tonnage of imports increased by more than 70 percent in one year to 10.8 million net tons, the level has not been below 10 million net tons in any succeeding year. Thus, 1965 marks the beginning of the era in which imported steel has been a major factor in the U.S. market.

Comparisons of Carbon and Specialty Steel Imports

Imports of carbon steel completely dwarf alloy and stainless steel in terms of total tonnage. Table 6-1 shows that carbon steel accounts for about 95 to 96 percent of all steel imports into the United States, followed by alloy steels and stainless steels. Although carbon steel imports as a percentage of the total have remained reasonably steady over the 1970-1980 period, imported alloy steels have recently begun to play a more important role.

An examination of the market share of imports by type of steel reveals a slightly different pattern. Despite the small tonnages of stainless steel imports in comparison with carbon steel, the market share held by stainless steel imports is similar to that held by carbon steel imports (Table 6-2). In the period

TABLE 6-1 Total Imports by Type of Steel (millions of net tons)

	Carbon		Alloy		Stainless	
Year	Tonnage	Percentage of Total	Tonnage	Percentage of Total	Tonnage	Percentage of Total
1970	12.83	96.1	0.35	2.6	0.18	1.3
1971	17.69	96.7	0.42	2.3	0.19	1.0
1972	17.09	96.6	0.45	2.5	0.15	0.9
1973	14.60	96.3	0.43	2.9	0.13	0.8
1974	15.61	96.4	0.41	2.6	0.18	1.0
1975	11.39	94.9	0.45	3.7	0.17	1.4
1976	13.65	95.4	0.48	3.4	0.18	1.2
1977	18.21	96.0	0.58	3.1	0.18	0.9
1978	20.09	95.5	0.75	3.5	0.20	1.0
1979	16.62	94.9	0.73	4.2	0.17	1.0
1980	14.78	95.4	0.56	3.6	0.15	1.0
1981	18.62	93.6	1.09	5.5	0.19	1.0
1982	15.38	92.3	1.08	6.5	0.20	1.2

SOURCE: U.S. Bureau of the Census.

1970-1982 the average percentages of imports were 18 for carbon, 6 for alloy, and 16 for stainless steel.

Despite the general upward trend in total carbon steel import tonnages and percentages, the pattern is not uniform among individual shape groups; in terms of market penetration, there are marked differences in both absolute magnitudes and trends. Those products that have experienced the most competition from

TABLE 6-2 Imports as a Percentage of Total Apparent Consumption[a] by Grade of Steel

Year	Carbon	Alloy	Stainless
1970	14.3	5.3	22.1
1971	18.7	5.8	22.5
1972	17.5	5.6	15.8
1973	13.0	4.6	11.0
1974	14.2	4.1	12.7
1975	14.3	5.2	19.7
1976	14.9	5.9	15.6
1977	18.9	6.4	14.5
1978	19.3	7.0	15.2
1979	16.3	6.5	11.8
1980	17.4	6.2	13.0
1981	20.0	9.7	15.0
1982	22.6	14.9	19.2

[a] Total apparent consumption = total shipments + imports - exports.

SOURCES: U.S. Bureau of the Census; American Iron and Steel Institute, *Annual Statistical Report*, various years.

imports in recent years include pipe and tubing, plate, and structural shapes. The market share of imports in each of these product groups has been on the order of 30 percent since 1978. Imports have also accounted for a larger than average share of wire products, galvanized (and other coated) sheet and strip, wheels and axles, and semifinished products.

REASONS FOR INCREASED STEEL IMPORTS

In the past 25 years, the United States has changed from a net exporter to a substantial importer of steel, with current conditions suggesting that the trend will not reverse itself. The reasons for this trade metamorphosis are found in a diverse yet interlocking set of circumstances concerned with technology, economic forces, and labor relations. These issues have been dealt with in the literature by a number of authors who have emphasized different, and sometimes conflicting, reasons for the increasing market share of imported steel, with the causal relationships also under debate.[1]

Import Price Versus Domestic Price of Steel

It is generally agreed that foreign producers have used the price mechanism to penetrate the U.S. steel market. They have, in most cases, undercut the prices of comparable quality domestic steel (except during the boom year of 1974), while the U.S. producers have been unwilling or unable to meet these lower prices.

The question of why imported steel is priced lower than that produced domestically is at the crux of the debate. There are basically three hypotheses for explaining lower foreign prices. The first is that foreign producers enjoy an actual cost advantage over U.S. producers. The second is that no cost advantage exists, but unfair or illegal trade practices lead to lower import prices. The third is that foreign producers have been willing to accept lower profit margins when the market for steel is weak.

Relative international production costs were discussed in Chapter 3. It was noted that on the order of 80 percent of U.S. capacity in 1980 was competitive with the landed cost of steel produced in Japan. Since the Japanese are considered to be the most efficient producers in the world, it follows that a greater percentage of U.S. capacity is competitive with producers from other countries. There are two problems with focusing on relative total costs of production as they existed in 1980. First, as discussed in Chapter 3, fluctuations in exchange rates, capacity utilization, and other factors lead to comparatively rapid changes in relative production costs among various countries over time. (Along these lines it is interesting to note that the Japanese competitive position in the world market has also declined in recent years.) Second, steel is not always priced in the world market to recover the full cost of production. In a competitive market it is expected that firms will continue to produce as long as they can cover their variable (cash) cost of production. Thus, when prices are determined by supply-demand interactions as they appear to be in the world market, considerable fluctuations may occur, depending on world production capacity and the level of industrial activity. Comparisons of U.S. prices with home-country and export prices of selected countries in recent years are shown in Table 6-3. It appears that the strength of the dollar and supply-demand pricing are factors that have led to relatively low prices of imported steel in the U.S. market in recent years. Just how much of this price advantage may be attributable to an actual cost advantage is a subject of hot debate, however. In particular, there have been frequent charges by domestic producers of dumping and government subsidization of foreign steel producers.

The 1974 amendments to the federal antidumping law added a cost of production test to the criteria for establishing the existence of dumping. Imports sold at prices that are insufficient to cover the full cost of production over a reasonable period may violate the antidumping law if these imports injure the domestic industry or its workers, even though "full cost" by trade law standards includes a profit margin greater than most foreign firms normally seek. With demand for steel products depressed almost continuously since the 1974-1975 recession, world steel prices have been relatively low. Many producers have been unable to cover their costs due to these low prices in world and domestic markets. Even the most efficient producers in the world over the previous decade, the Japanese, have made only modest profits since the 1974-1975 recession.

In some countries, older steel plants have been faced with the prospect of closure. This is particularly true of a number of European countries, such as Belgium, Luxembourg, France, and the United Kingdom. Only some of these facilities might have survived (at different asset values) if they had been reorganized through a bankruptcy proceeding. In many instances, these imperiled plants or companies have been supported by their governments. Government ownership, however, obscures the economics of investment and production decisions and makes it very difficult to know which facilities are being operated beyond their economic lives and which are viable in the long run.

It is probable that in the absence of government intervention more capacity would have been retired in Europe by now. (It

TABLE 6-3 Home Country Steel List Prices and World Export Prices ($ per metric ton; index value USA = 100)

	United States		Japan (big buyer)			Japan (market)			West Germany			United Kingdom			France		
	$	Index	Yen	$	Index	Yen	$	Index	Marks	$	Index	Pounds	$	Index	Francs	$	Index
Home Country List Prices																	
1974	276	100	55,549	190	69	83,392	286	104	823	318	115	118	277	100	1,446	301	109
1978	431	100	91,867	441	102	93,153	448	104	853	426	99	229	439	102	1,917	426	99
1979	476	100	92,063	422	89	98,371	451	95	875	478	100	242	514	108	2,008	472	99
1980	513	100	97,430	432	84	101,682	450	88	930	512	100	258	600	117	2,191	519	101
1981	571	100	101,777	463	81	97,276	445	78	942	415	73	261	543	95	2,269	419	73

	Contract		Spot		Intra-EEC		
	$	Index	$	Index	Marks	$	Index
Export Prices							
1974	310	112	390	141	805	311	113
1978	343	80	347	81	810	404	94
1979	404	85	407	86	854	466	98
1980	431	84	422	82	876	483	94
1981	450	79	391	69	887	390	68

NOTE: All figures are composites and assume a U.S. major mill 1977 carbon steel shipment mix. Home prices are F.O.B. the plant, export prices are F.O.B. the port of export, and intra-EEC price is C.I.F. the West German/French border.

SOURCE: World Steel Dynamics, "The Steel Strategist," No. 4, Paine Webber Mitchell Hutchins, Inc., August 1981.

should also be pointed out that some U.S. mills have benefited from Economic Development Administration [U.S. Department of Commerce] subsidies--although they have accounted for a very small share of total output--and that indirect subsidies have accrued to the domestic steel industry [as well as to all U.S. manufacturing] in the form of artificially low energy prices in the past.) A compilation of news releases to document the case that many international steel producers are either government-owned or government-subsidized has been assembled by the AISI.[2]

While government ownership does not necessarily connote the extension of subsidies, it certainly facilitates them in the current situation. It is very difficult to measure the extent of these subsidies since the government's assumption of liabilities or purchase of equity is not necessarily a dollar-for-dollar subsidy. With government ownership, however, political decisions inevitably substitute for decisions based on economics; hence, uneconomical plants may have their lives extended. Investments may be based upon noneconomic factors such as the geographical distribution of employment. In the long run, such decisions weaken foreign producers as competitors for the U.S. market, but in the short run they can add to output just when the market is very weak.

Some of these foreign trade issues are now being adjudicated in the courts. In January 1982 seven major domestic steel producers separately filed more than 190 antidumping and countervailing duty complaints against the seven major steel producers in the European Economic Community (EEC) as well as Brazil, Romania, South Africa, and Spain. The suits cover 11 product categories and 132 product and country combinations, and represent about 20 percent of U.S. carbon steel imports.[3] A summary of these suits is provided in Table 6-4.

U.S. Labor Negotiations

In addition to price differentials, another catalyst for increased steel imports has been the hostile tone of labor negotiations between the U.S. steel industry and the United Steelworkers of America (USW). The last industrywide strike, lasting 116 days in 1959, ushered in a new era of net steel importation by the United States. Although another prolonged general strike has not occurred since, labor negotiations in a number of years (1965-1969, 1971) went down to the wire before a settlement was reached. Dramatic increases in imports occurred in these years as consumers built contingency inventories and established alternate sources of supply in anticipation of another extensive work stoppage.

This hedge buying ceased to be a factor in the import markets when the Experimental Negotiating Agreement (ENA) was estab-

TABLE 6-4 Summary of Steel Antidumping (AD) and Countervailing Duty (CVD) Cases Filed January 11, 1982[a]

Product	Structurals		Plate		Carbon	Alloy	Carbon	Alloy	Hot Rolled Sheet[b]		Cold Rolled Sheet[b]		Galvanized Sheet	
Country	AD	CVD	AD	CVD	CVD	CVD	CVD	CVD	AD	CVD	AD	CVD	AD	CVD
Belgium	US Beth	All	US Beth	All	Five	Five	Five	Five	US Beth	All	US Beth	All	US Beth	All
West Germany	US Beth	All	US Beth	All	Five	Five	Five	Five	US Beth	All	US Beth	All	US Beth	All
France	US Beth	All	US Beth	All	Five	Five	Five	Five	US Beth	All	US Beth	All	US Beth	All
Italy		Five	US Beth	All	Five	Five	Five	Five	US Beth	All	US Beth	All	US Beth	All
Luxembourg	US Beth	All	Beth	Five Beth	Five	Five	Five	Five	Beth	Beth Five	Beth	Beth Five	Beth	Beth Five
Netherlands		Five	US Beth	All	Five	Five	Five	Five	US Beth	All	US Beth	All	US	US Five
United Kingdom	US Beth	All	US Beth	All	Five	Five	Five	Five	US	US Five	US	US Five	US	US Five
Brazil		Five		US Five	Five	Five	Five	Five		Five		Five		Five
Romania	Five		US Five		Five	Five	Five	Five		Five		Five		Five
South Africa		Five		US Five	Five	Five	Five	Five	Five			Five		Five
Spain		US Five		US Five	Five	Five	Five	Five		US Five		US Five		US Five

[a] US–United States Steel Corporation; Five–Republic, National, Inland, J & L, and Cyclops; Beth–Bethlehem Steel Corporation; and All–U.S. Steel, Bethlehem, Republic, National, Inland, J & L, and Cyclops combined.

[b] For all European Economic Community countries, both hot and cold rolled sheet filings include strip, both AD/CVD (except cold rolled sheet from the Netherlands).

SOURCE: Trozzo (1982).

lished in March 1973. The representatives of the USW and of 10 principal steelmakers (Allegheny-Ludlum, Armco, Bethlehem, Inland, Jones & Laughlin, National, Republic, U.S. Steel, Wheeling-Pittsburgh, and Youngstown) agreed that the USW would not strike nationwide (they had the right to strike a single plant over local issues) and that the companies would not engage in employee lockouts during periods of labor negotiation. This agreement has helped to stabilize inventory buildups by both the steelmakers and the manufacturers and hence aided in smoothing fluctuations in steel operations and employment practices. It is also postulated that the ENA helped restrict the penetration of imports below the levels that might have been attained in the most recent negotiation year. The ENA provided several substantial wage and benefit promises to the USW membership that were to be applied to future employment agreements. First, it guaranteed a minimum annual real wage increase of 3 percent. Second, the cost-of-living clause was to be included in future agreements. Third, a one-time $150 bonus payment was to be provided for each covered worker. This represented the approximate savings to the industry that would result from the increased stability expected under the ENA.

The ENA was originally negotiated to be in effect for the 1974 bargaining and was amended to remain in effect for the 1977 and 1980 negotiation periods. In the eyes of both the steel companies and the USW, the ENA was a success in 1974 and 1977. Delicate issues were resolved without going to arbitration. The absence of a strike threat eliminated strike hedge buying, which had swelled inventories and imports in the past. In the 1983 bargaining session the high wage guarantees were reduced, and it remains unclear if the ENA will survive.

General Agreement on Tariffs and Trade (GATT)

The landed cost of imported steel to U.S. consumers depends on (1) the foreign mill net price, (2) transportation and other miscellaneous costs, and (3) the U.S. import tariff fees. Unilateral reduction of the tariff fees in major nations was the aim of the sixth tariff negotiating conference sponsored by GATT. This conference, known as the "Kennedy Round," terminated on June 30, 1967, after three years of deliberation. It resulted in a five-stage reduction of steel tariffs from a weighted average of 7.44 percent in 1966 to 6.5 percent in 1972. Other major countries lowered their tariff fees on steel by generally more than the United States, with the result that steel tariffs are more closely aligned among major steel trading nations.

Voluntary Restraint Agreement (VRA)

The record level (at that time) of steel imports during the labor negotiation year of 1966 evoked intense pressure in Congress to legislate trade quotas to protect the U.S. steel industry. In the wake of these developments the steel producers of Japan and the EEC, in letters to the U.S. Secretary of State, voluntarily agreed to restrict their exports of steel to the United States in the years 1969, 1970, and 1971. The VRA was to limit exports to the United States to a total of about 14.0 million net tons, with Japan supplying 5.75 million tons and the EEC, 5.57 million tons. The remaining approximately 2.7 million tons was allocated to other steel exporters, primarily Canada and the United Kingdom, although neither was a party to the agreement. The allotted tonnages were allowed to rise 5 percent each year during the pact.

Imports did decline in 1969 and 1970 to approximately the agreed-upon levels, although it is difficult to determine whether this occurred because of the VRA or a strong world market for steel in those years. The uncertainty of the 1971 labor talks gave rise to another record year of imports and rendered the VRA virtually useless. An interesting consequence of the VRA in its first year (1969) was that, even though the total tonnage of imports was only 0.2 percent above the agreed-upon levels, a shift to higher-priced products occurred. This actually resulted in increased alloy and stainless steel imports during the agreement years; imports of higher-priced carbon steel shapes such as cold-finish bars, pipe and tubing, tin mill products, and wheels and axles also increased during this period.

Despite these problems, a second VRA was agreed upon for the years 1972, 1973, and 1974 on a modified basis. Changes from the first VRA included a reduction in the allowable growth rate to 2.5 percent per annum, the inclusion of the United Kingdom in the agreement, and the consideration of product mix and geographical mix when setting the limits.

Imports for these years were below the 1971 record levels, but again the success of the VRA was obscured by other factors: another boom in world steel demand in 1973-1974, which diverted steel from the U.S. market; the ENA, which averted crisis labor bargaining in 1974; and a dollar devaluation, which increased the cost of imports to the United States.

The Trigger Price Mechanism

In 1977 surging imports and financial hardship caused serious repercussions throughout the steel industry in the form of worker layoffs and plant closings. As a result President Carter established a special task force to explore the steel industry's problems and generate a plan of assistance. The task force, headed by Under Secretary of the Treasury Anthony Solomon, was composed of experts from various government agencies.

Part of the comprehensive program to assist the steel industry was the establishment of a trigger price mechanism (TPM) for imported steel products. Trigger prices were defined as those prices below which steel mill products could not be imported without automatically triggering an expedited antidumping investigation by the U.S. Department of the Treasury. Prior to the advent of this mechanism, dumping investigations would begin only after a complaint was received from a U.S. steel producer claiming injury from imports, and countervailing duties were leveled only after two more criteria were satisfied. The first was that the U.S. Department of the Treasury must find that the item was sold in the United States below cost or below the exporter's home market price. The second, if the first was met, was a verification by the International Trade Commission (ITC) that the imported products had injured the domestic producers.

It was hoped that the TPM would ensure fair prices of imported steel in the U.S. market and speed up any investigations into illegally low and injurious pricing by foreign producers. Trigger prices were announced by the U.S. treasury department for each major steel product imported in significant quantities. The price included a base plus extras, if any, and transportation charges from Japan. Costs of production in Japan, considered to be the lowest-cost foreign producer, were used to construct the base price. Extras are charges above the base price reflecting specifications for factors such as size, thickness, and chemistry. Transportation charges include inland freight, loading, ocean freight, insurance interest, and wharfage charges, but exclude U.S. import duties or importer's sales commissions. These charges were calculated separately for each of four areas of port of entry into the United States: West Coast, East Coast, Gulf Coast, and Great Lakes regions. The trigger price for each shape was updated quarterly to reflect any changes in costs and exchange rates.

Administered by the U.S. Department of the Treasury, the TPM was partially implemented in February 1978, but did not take full effect until May of that year. There were few complaints with the system for approximately one year after its implementation. However, by mid-1979 the domestic industry was becoming discontent.

Although trigger prices were increased by 17 percent in the first quarter of 1979, there was no change during the second quarter, and the trigger was decreased during the second half of the year. These fluctuations were primarily in response to changes in exchange rates. As shown by Table 6-5, concurrent

TABLE 6-5 Steel Trigger Prices and the Producer Price Index

	Trigger Prices[a]		Producer Price Index[b] Finished Steel Mill Products[c]	
Year and Quarter	$/Short Ton	Percent Change	1967 = 100	Percent Change
1978				
II	300.76	–	252.2	–
III	318.73	6.0	257.3	2.0
IV	329.42	3.4	261.1	1.5
1979				
I	352.53	7.0	271.1	3.8
II	352.53	0.0	275.4	1.6
III	347.54	-1.4	283.7	3.0
IV	347.54	0.0	288.9	1.5
1980				
I[d]	358.31	3.1	292.9	1.7
IV	401.73	12.1	308.6	5.4
1981				
I	405.18	0.9	323.3	4.8
II	422.95	4.4	330.8	2.3
III	424.39	0.3	343.4	3.8
IV	424.39	0.0	347.3	1.1
1982				
I[d]	424.39	0.1	–	–

[a] *Federal Register* notices.

[b] Average for each quarter.

[c] U.S. Department of Labor, Bureau of Labor Statistics, unpublished data.

[d] The trigger price mechanism was suspended on March 24, 1980, and then reinstated on October 21, 1980 (45 F.R. 20150; 45 F.R. 66833). It was suspended again on January 11, 1982.

SOURCE: Trozzo (1982).

with this decrease were steadily increasing prices of domestic steel products, thus making imports relatively more attractive to consumers.

At the same time that the trigger price calculations were allowing imports to become more price-competitive, the demand for steel products began to decline. The result was that domestic production rates fell below 75 percent of capacity by December 1979 and imports increased to greater than 18 percent of consumption in November and December of that year. Domestic producers closed plants, and the U.S. Steel Corporation filed antidumping petitions against seven EEC countries in March 1980. Soon thereafter the U.S. Department of Commerce (DOC) announced that it would suspend the TPM to devote its resources to the dumping case.

In May 1980 the ITC found that there was a "reasonable indication" that "material injury" had been suffered by the domestic industry as a consequence of the imports cited in the U.S. Steel Corporation complaints.[4] Following extensive discussions by U.S. and European officials aimed at reaching a political settlement to forestall the implementation of dumping penalties, a new "Program for the American Steel Industry" was announced on September 30, 1980, by President Carter.[5]

The cornerstone of this program was a new, improved TPM that was intended to be effective for a 5-year period. The essential elements of the new TPM were:

- a 12 percent increase in the base price compared with its level at the time of suspension;
- use of a 36-month moving average of the dollar-yen exchange rate instead of recent values for converting Japanese production costs in order to avoid large fluctuations in the base price;
- addition of a "surge" mechanism wherein a formula was devised to trigger an expedited investigation by the DOC whenever imports exceeded a fixed percentage of domestic consumption;[6] and
- a set of procedures for importers to obtain preclearance from the DOC to sell below the trigger price if the shipper could demonstrate production and shipping costs that were less than the current trigger price.[7]

The new steel program, which included the revised TPM, was initiated on October 21, 1980. Partly in response to the new steel program and partly because economic conditions in the domestic industry had improved and imports had decreased, U.S. Steel announced its immediate withdrawal of the dumping complaints.[8]

The apparent contentment of domestic producers with the new trade rules was short lived. Trigger prices were increased by 5.6 percent from the fourth quarter of 1980 to the fourth quarter of 1981. During the same period the producer price index for finished steel products increased by 12.5 percent. Spurred partly by the relative competitive advantage of the rising value of the dollar, imports increased dramatically in 1981, accounting for a record (at the time) 19.1 percent (19.9 million tons) of the domestic market. Moreover, while shipments from domestic producers were declining steadily during this period, the share of the domestic market accounted for by imports increased from 13.9 percent in the first quarter, to 18.2 percent in the second, to 21.5 percent in the third, to 26.3 percent by the fourth quarter of 1981. There were reports in the press[9] that, in addition to those foreign producers that had obtained preclearances to sell at below trigger price levels, others were doing so covertly. It was also reported that a number of trading methods were devised to evade the spirit, if not the letter, of the TPM.[10]

In response to pressures from the domestic industry and the Congressional Steel Caucus,[11] in November 1981 the DOC initiated five antidumping and countervailing duty cases against foreign producers and suspended the preclearance system.[12] In preliminary rulings by the ITC in December 1981 and January 1982, it was determined that there was a reasonable indication of injury to domestic producers from imports of steel plate from Belgium, Brazil, and Romania; imports of hot-rolled sheet from France,[13] and imports of sheet piling from Canada.[14] However, in January 1982, stating that the Europeans could not "convince the American industry that the TPM can continue to be an effective means of enforcing U.S. trade laws,"[15] domestic producers filed the massive antidumping and countervailing duty suits referred to earlier in this chapter.

After the suits were filed, the DOC terminated the cases it had initiated and suspended operation of the TPM because of duplication with the private filings.[16]

RECENT EVENTS

On July 12, 1984, in response to the largest of a series of steel complaints brought before it in recent years, the ITC recommended to President Reagan that he use his powers, under the Trade Act of 1974, to impose increased quotas and tariffs on approximately 70 percent of the carbon steel products imported by the United States. If the recommendation is closely followed, carbon steel imports should be restricted to about 17 percent of domestic consumption. In 1983 imports accounted for 20.5 percent, and by mid-1984 they had captured close to 25 percent of the domestic market. Specifically, the plan calls for the following restrictions on five major categories of carbon steel products:

- Semifinished products. Up to 15 million tons could be imported at current tariff levels. Additional quantities would face 15 percent increases in tariff levels (currently about 5.1 percent) for the first three years and 10 percent increases for the last two years. Since the quota is almost twice as large as 1983 import levels, the intent is to impose a ceiling on future imports. Such a restriction could effectively halt plans of domestic producers to close only the primary end of selected facilities and to import large quantities of semifinished products for further processing in the United States.

- Plates. For these products an annual quota of 2.1 million tons would be imposed. In 1983 this quantity would have been about 27.7 percent of domestic consumption. The ITC forecasts that 2.1 million tons would account for about 21.2 percent over the next three years, and 23.3 percent of U.S. consumption for the final two years of the plan.
- Structurals. There would be no quotas on light structural products produced mainly at minimills. For heavy structural steels, a quota of 2.1 million annual tons would be established. In 1983 this would have represented 33.9 percent of the domestic market. The ITC projects that this figure would amount to about 28.9 percent and 31.8 percent of domestic consumption over the first three and final two years of the proposed 5-year period, respectively.
- Wire and wire products. Imports of wires would be restricted to 400,000 tons annually, accounting for 24.5 percent of the market for the first three years and 26.9 percent for the final two years according to ITC projections. Wire products would not be limited by import quotas, but would face a 12 percent tariff increase, declining to 10 percent over the final two years. In mid-1984, tariffs on wire products ranged from 0 to 7 percent.
- Sheet and strip. In this, the largest tonnage category of imports would be restricted to an annual quota or a specific market share (depending on the product), whichever is highest. For cold-rolled products, the quota would be 1.9 million tons, or 10.6 percent of domestic consumption in the first three years, and 11.7 percent in the last two. For hot-rolled products, the limit would be 1.8 million tons, or 11.0 percent of consumption in the first three years, and 12.1 percent the final two years. In 1983, imports of cold-rolled and hot-rolled steel products were 15.2 and 14.4 percent of domestic consumption, respectively. For galvanized products, the quota would be 1.6 million tons, or 21.4 percent of the U.S. market in the first three years followed by 23.5 percent in the final two years. For other sheet and strip products, the limit would be 400,000 tons, or 6.4 percent of consumption in the first three years and 7.0 percent in the final two. In 1983 imports were 13.0 percent of the market in this category.

According to law, the President had until September 24, 1984, to decide whether to accept, modify, or reject the ITC recommendations. The case is by no means clear-cut and is fraught with controversy. Although all the other cases brought before the ITC in recent years contend that steel was being exported to the United States at unfairly low and/or subsidized prices, this one--initiated by Bethlehem Steel and the USW--alleges that imports, fairly priced or not, have reached levels that are high enough to entitle the industry and its workers to protection.

The ITC approved the measure on a 3 to 2 vote, just as it had voted in its earlier determination that the industry was being injured by imports. In announcing its recommendations, the ITC said that protection mechanisms should be implemented only if the steel industry commits to using the funds generated by the increased shipments and prices for modernization. According to ITC Commissioner Rolf,[17] a comprehensive plan should be submitted by the industry--including details on financing, capital investments, research, marketing, and distribution--within 120 days of the effective date of the quotas and tariffs. "If these reviews do not reveal meaningful efforts to adjust by all involved in the steel industry, the relief should be terminated,"[18] he said. The two ITC commissioners who dissented said that they did not believe the industry had been sufficiently injured by imports to justify protection.

Although the industry seems to be mostly satisfied with the proposed plan, the chairman of Bethlehem Steel said that his company would continue to push for action by Congress on those products not covered by quotas (e.g., semifinished steel) regardless of what the President did.[19] Other companies would not be happy with quotas on semifinished steel because of their current and future dependence on imported semifinished products for finishing into a variety of sheet and plate products. For instance, LTV, the second largest U.S. producer, currently is importing steel from Brazil for finishing at its Lake Michigan plant and the long-term survival of at least three domestic plants (in Gadsden, Alabama; Fontana, California; and Fairless, Pennsylvania) is said to depend on access to foreign semifinished steel.[20]

In addition to leading to higher prices for consumers, the ITC plan would also anger U.S. trading partners, particularly in Europe, Japan, and Canada, and complicate debt repayment by developing countries in the Far East and Latin America such as South Korea and Brazil. Soon after the ITC recommendations were announced, spokespersons for Canada, the EEC, Japan, and Argentina severely criticized the plan. The EEC warned that the 1982 arrangement between the Common Market and the United States limiting European steel to 5 percent of the domestic market could be endangered by further steel protection and that the EEC could take retaliatory action against a range of U.S. exports.[21]

Developing countries could be most seriously hurt since the ITC used the 1979-1981 data on import shipments to determine allocations among countries for future quotas. Such a basis for calculation favors historical suppliers, such as Japan and the EEC, because much of the post-1981 import surge came from countries such as Brazil, Argentina, Mexico, South Korea, and South Africa.[22]

In late September 1984 the President rejected the ITC recommendations and announced that he would seek to arrange for a voluntary quota system and conduct bilateral negotiations with our trading partners.

NOTES

1. See Trozzo (1982), AISI (1980), GAO (1981), Crandall (1981), Mueller and Kawahito (1978), and AISI (1981).
2. AISI (1980, 1981).
3. For a summary of these suits see Trozzo (1982).
4. Trozzo (1982).
5. Ibid.
6. The provisions of the surge mechanism were: (1) the industry must have been operating at less than 87 percent capacity utilization for the surge mechanism to be operative; (2) if imports exceeded 13.7 percent of apparent consumption, the DOC was to make a special review to determine if the TPM was being evaded, thereby providing grounds for appropriate action; and (3) if imports exceeded 15.2 percent of apparent domestic consumption, the DOC was to make an expedited study to determine if the imports resulted from dumping, foreign government subsidization, or fair competition. The U.S. Trade Representative was also committed to initiate discussion with the foreign government(s) involved.
7. Actually, the preclearance mechanism was added after the implementation of the new trigger price mechanism.
8. Trozzo (1982).
9. See Trozzo (1982) and The Wall Street Journal (1981).
10. Trozzo (1982).
11. See U.S. Import Weekly (1981).
12. See Trozzo (1982) and The Journal of Commerce (1981).
13. See Trozzo (1982) and The Journal of Commerce (1981).
14. See Trozzo (1982) and The Journal of Commerce (1982).
15. See Trozzo (1982) and The New York Times, January 9, 1982, p. 31.
16. Trozzo (1982).
17. The New York Times, July 12, 1984.
18. Ibid.
19. The Wall Street Journal (1984).
20. Ibid.
21. Ibid.
22. Ibid.

7

Problems of the Domestic Industry

The competitive position of the steel industry of the United States has eroded to the extent that domestic production has decreased from 50 percent to about 17 percent of world steel supply over a 25-year period, and the United States has become one of the few developed nations with insufficient capacity to meet the peak demands of its domestic market. The major problem facing U.S. firms is one of overcapacity in the world steel market. A primary reason for the overcapacity is that the world steel market does not work efficiently. It does not work efficiently because of factors such as (1) foreign government investment in steel plants, particularly in developing countries; (2) foreign subsidies to steel plants that increase output and reduce the probability of plant closure; and (3) foreign protectionism in other countries' domestic markets for steel products.

The overcapacity has resulted in a situation where markets for steel products have been depressed roughly three out of every four years for the past two decades, with little change likely in the future. Depressed world markets have contributed to a poor record of profitability for domestic producers in recent years. Other factors that led to the poor financial performance include (1) relatively high costs of some domestic plants because of old production facilities, relatively high labor costs, and costs of compliance with government regulations and (2) relatively low revenues because of price controls and the loss of market share due to the reluctance of domestic producers to engage in supply-demand pricing.

PROFITABILITY

The data shown in Table 7-1 make it clear that the U.S. steel industry has experienced a low accounting rate of return on equity over the past 25 years when compared with other manufacturing

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TABLE 7-1 Rate of Return on Equity after Taxes (percent)

Year	Iron and Steel	Average of Other Manufacturing Industries
1955	13.5[a]	12.6
1956	12.7[a]	12.2
1957	11.4[a]	11.0
1958	7.2	8.6
1959	8.0	10.4
1960	7.2	9.2
1961	6.2	8.8
1962	5.5	9.8
1963	7.0	10.3
1964	8.8	11.6
1965	9.8	13.0
1966	10.3	13.5
1967	7.7	11.7
1968	7.6	12.1
1969	7.6	11.5
1970	4.3	9.3
1971	4.5	9.7
1972	6.0	10.6
1973	9.5	12.8
1974	16.9[a]	14.9
1975	10.9	11.6
1976	9.0	14.0
1977	3.6	14.2
1978	8.9	15.0
1979	8.8	16.5
1980	9.0	14.0
1981	11.2	13.7
1982	-15.8	9.3
1983	-17.8	10.6

[a] Years in which the rate of return of the iron and steel industry exceeded the average.

SOURCE: Federal Trade Commission, Quarterly Financial Reports for Manufacturing Corporations.

industries. Among the 41 manufacturing industries considered, the iron and steel industry's rate of return ranked at or near the bottom most of the time. In fact, since 1955 its rate of return exceeded the average of all industries only four times. Of these, three were in the late 1950s and the fourth was during the boom year of 1974.

The data tabulated in Table 7-1 are from only one of a number of reports that have noted the historically poor financial performance of the domestic steel industry. The most common analytical measure of financial performance has been the rate of return on equity, or a similar variant, of the steel sector compared with that of the total manufacturing sector. Comparisons of profitability made in such a manner, however, should be used with caution because the returns are not adjusted for risk (i.e., less risky industries should be expected to have lower rates of return) and are subject to inconsistent accounting practices that may be misleading in a capital-intensive industry such as steel.

A recent study of the rate of return required for investment in the steel industry[1] has shown that all three segments of the industry--integrated, specialty, and scrap-based--are perceived by financial markets to be less risky than the average of all manufacturing industries in the United States. Thus, the rate of return that must be demonstrated for investment in the steel industry should not be as high as that for the average of all manufacturing.

RECENT EVENTS RELATED TO DOMESTIC STEEL PRODUCTION

Since the beginning of 1981 there has been sobering domestic economic news from the industry. Early in 1981 the Wisconsin Steel Company succumbed to bankruptcy. In November 1981 Kaiser Steel Corporation, having experienced losses for 18 straight calendar quarters, announced that it would discontinue its basic raw steel production operations at Fontana, California, in 1983. In December 1981 McLouth Steel Corporation of Detroit, a relatively modern producer of products that are highly dependent on the automotive industry, filed for reorganization under Chapter 11 of the Bankruptcy Act.[2] Also in 1981 the U.S. Steel Corporation announced plans to close its Edgar Thomson works. In 1982 National Steel announced plans to sell its Weirton, West Virginia, facilities.

The adverse economic news is not confined to companies with older plants and equipment. Inland Steel, which has attempted to modernize and has invested $1.5 billion since 1974 (25 percent for pollution control and 50 percent more than its net worth going into that period), reported a net loss in the second quarter of 1982. The loss was the fourth in eight quarters for Inland, which had previously gone 40 years without losing money. Consequently, Inland dropped from first to sixth place in terms of return on equity among the six largest domestic producers.

As a result of the low rate of capacity utilization in the domestic industry, unemployment among steelworkers has been quite high since 1981. An American Iron and Steel Institute (AISI) survey of its members showed that the average number of hourly wage employees, which was 300,000 in May 1981, had declined to 258,000 by December 1981, at that time the lowest level reported since records were first initiated in 1933. By 1983 the number of wage earners had declined to 243,000. Moreover, several communities that depend to a large extent on the steel industry for their economic livelihood have suffered severe economic consequences.

All of the economic reports from the steel industry were not bad, however. There was one positive sign that may point to a better financial performance, at least in the short term as the economic recovery continues. Due to the restructuring process that has been proceeding in the past few years (i.e., closing high-cost facilities), AISI data[3] indicate, the net income of member companies in 1980 was second only to the record year of 1974, when the industry was operating at essentially full capacity. Although these figures are not in real dollars and thus overstate the 1980 numbers relative to those of 1974, given the 73 percent average capacity utilization for 1980, the profitability results are interesting.

The first three quarters of 1981 also yielded positive financial results, as the net income of member companies was about twice that of the same period in 1980. The sharp drop in capacity utilization during the fourth quarter of 1981 brought a concurrent decline in net income, but only one major integrated producer reported a fourth-quarter loss. Results for 1982-1983, however, were disastrous. The seven major integrated producers in the United States lost an average of about $149 per ton in the fourth quarter of 1982; the average loss in the first quarter of 1983 was about $100 per ton, and most integrated producers continued to operate at a loss throughout 1983.

All of the integrated firms in the United States cut production drastically during 1982--U.S. Steel by about 50 percent to less than 11 million tons and Bethlehem Steel by about 35 percent to less than 10 million tons. In December 1983 U.S. Steel announced the closing of three of its major plants and parts of 12 others, resulting in the loss of about 6 million tons of raw steel capacity and more than 15,000 jobs. The recession was not restricted to the U.S. market. Similar reductions in output were recorded in Europe, and the top 10 firms of the market economies of the world produced 127 million tons in 1982, compared with 153 million tons in 1981.

By 1983 the recession in the steel market had run its course in the United States, and a slow recovery was under way. Rates of capacity utilization, which were as low as 29.8 percent in December of 1982, had improved to more than 50 percent by late March 1983 and continued to increase at a slow but steady rate throughout most of 1984.

The recession of the early 1980s contributed to several important structural changes in the domestic steel industry. First, the industry continued to retire older, inefficient plants and equipment. Second, a new agreement was reached with the United Steelworkers union, resulting in a wage decrease of $1.25 per hour and a reduction in certain benefits. Both of these changes should leave the domestic industry in a better position to profit from the increased production opportunity attendant upon an economic recovery.

A third important change concerns pricing policy. Prior to 1982 the domestic industry appears to have pursued a policy of cost-plus pricing; that is, domestic producers attempted to charge a price that reflected the average long-run cost of production plus a "reasonable" markup. The deep recession of 1982, however, resulted in a complete disintegration of cost-plus pricing and a shift to supply-demand pricing. By December of 1982 average price realizations of U.S. producers were 14 percent lower than they were one year previously. If the change in pricing policy is not temporary, there could be two important implications: On the one hand, in the near future, revenues (and therefore profits) will be lower for given levels of production; on the other, the market share of imports, particularly in the long run, could decline substantially if domestic consumers perceive that U.S. producers are willing to price their product according to the normal laws of competitive supply and demand.

FACTORS RELATED TO REVENUES AND COSTS

The problems faced by the steel industry are not new. As discussed in the introduction to this report, similar problems have occurred periodically for the past 20 years. However, the current set of problems is especially severe because of the deep recession in the world's developed economies and the concurrent recession in the international steel industry. As a result, considerable excess capacity has been generated among the world's steel producers and this has led to two conditions that have seriously hurt the U.S. producers: loss of share of the domestic market and lower prices. The first problem is largely the result of the failure of the domestic industry to engage in competitive supply-demand pricing. While it may be argued, as discussed in Chapter 4, that government financing and subsidies lead to market failure and the normal laws of competitive supply and demand do not work, the reluctance of U.S. producers to compete with imports on prices has undoubtedly led to a loss of market share.

In addition to the depressed world market for steel, the strong increase in the relative strength of the dollar has inhibited the ability of domestic producers to compete on the basis of cost. A major contributing factor to the rise of the dollar and to the weak domestic demand for steel was the high interest rate policy in the United States. High interest rates had a severe impact on the domestic industry, both by depressing demand for capital goods, such as automobiles, appliances, and ships, and by making imports more attractive. Note also that the competitiveness of domestic capital goods industries that use significant quantities of steel is impaired if domestic steel prices are higher than those in the international market. Thus, the domestic automotive industry, which has adhered to a "buy American" policy in the past, had to pay on the order of 25 to 30 percent more for its steel in 1977 and 1978 than did its Japanese counterpart.[4]

The foregoing discussion outlined the problems that the industry has faced on the revenue side of the ledger. Problems also exist on the cost side. A sharp decline in the consumption of an industry's product usually leads the industry to consider closing its least efficient operations. These decisions are based on projections of future revenues (which depend on future U.S. demand less imports and future prices), the costs associated with maintaining production while operating at inefficient levels of capacity utilization, the costs associated with modernization, other required expenditures, and the extent to which output can be expanded elsewhere.

In the U.S. steel industry there are a number of plants that because of their age and location are considered to be marginal on an economic basis even at reasonably high operating rates. For instance, 45 percent of the hot-rolling capacity for plate and strip in the United States was built prior to 1961 and only about 15 percent has come on line since 1971. Japan, on the other hand, has built about 60 percent of its hot-rolling capacity for plate and strip since 1961, with the larger percentage of this concentration in the period from 1966 to 1970.[5] Hot-roll plate and strip mills handle on average about 55 percent of the crude steel output of the Western world.

At low operating rates these marginal plants are unprofitable. It is not surprising then that, as has been pointed out, some have already been permanently closed. The variation in the age and efficiency of steel plants in the United States is quite large, and some of them could not be modernized economically under any circumstances because of their location, layout, and environmental constraints.

In addition to operating a number of older facilities, the industry has had to cope with relatively high labor costs and expenditures to comply with government regulation. Comparative labor costs were reviewed in Chapter 3. It was reported that in recent years total hourly compensation paid to steelworkers in the United States was about 25 and 40 percent greater than that paid to West German and Japanese steelworkers, respectively. It was shown in Chapter 3 that even major investments in technological improvements would not be enough to overcome our labor cost disadvantage. Costs of compliance with environmental regulations, although a problem in the past, are not expected to be of any major consequence in the foreseeable future.

Another problem with which the industry has been faced is the apparent lack of consistency of federal antitrust policy. In an attempt to consolidate and reduce costs by combining the most modern and optimally located facilities of two companies and shifting product mixes, domestic firms have experienced difficulties convincing the U.S. Department of Justice that such moves would not unduly restrict competition in the domestic market.

For instance, in September 1983 Republic and LTV announced a merger that would create the second largest U.S. producer. The Department of Justice opposed this merger, principally on the grounds that it would lead to increased market concentration and reduced competition among domestic producers. This decision, which apparently failed to take adequate account of the current and projected glut of steelmaking capacity in the world market, was severely critized in many quarters, including the executive branch, and by the Secretary of Commerce. Although the decision was later modified, allowing the Republic-LTV merger on the condition that some stainless steel operations be sold, a considerable amount of confusion still exists within the industry concerning the criteria for approval of mergers and acquisitions.

In another case, U.S. Steel and National Steel announced a plan for a merger in January 1984 that would have increased the capacity of the nation's largest steelmaker by about 6 million annual tons (the same as the announced closings by U.S. Steel in December 1983) and allowed it to shift its product mix more toward the flat-rolled products desired by the auto and consumer durables (e.g., appliance) industries. However, because of apparent opposition from the U.S. Department of Justice and the precedent of the initial Republic-LTV decision, U.S. Steel decided not to pursue the merger. As a result, National Steel was forced to look elsewhere for needed capital. In April 1984 NKK (Nippon Kokan) purchased 50 percent of National, the seventh largest U.S. producer.

In a separate incident, another foreign company, Nisshin Steel, Japan's sixth largest, purchased 10 percent of the financially troubled Wheeling-Pittsburgh Steel Company (eighth largest in the United States). In the transaction, Nisshin agreed to provide Wheeling-Pittsburgh with $35 million in capital, and the two firms agreed to build a coating mill in the Ohio Valley for rust-proofing flat-rolled products. Antitrust approval was not required because the deal was not a merger or acquisition.

NOTES

1. Baldwin, Tribendis, and Clark (1984).
2. Trozzo (1982).
3. AISI, Annual Statistical Report (1981).
4. Magaziner and Reich (1983), p. 155.
5. Marcus, Kirsis, and Hiramoto (1981).

8

Policy Alternatives and Scenarios

As late as 1981 the future size and location of steel production capacity was thought to depend on four major factors:

1. trade policy and regulations;
2. promulgation and enforcement of environmental regulations;
3. formulation of tax policies and other financial regulations; and
4. future growth of electric furnace capacity.

Since that time the third and fourth factors listed above appear to have diminished in importance. The world economic recession of 1981-1982 essentially eliminated the potential problems associated with near-term domestic expansion of electric furnace capacity by (1) creating a condition of excess supply and (2) eliminating pressure on the demand for ferrous scrap. The Reagan administration has implemented policies designed to alleviate the economic impact of environmental regulations on the domestic industry. Such policies include the extension of the compliance deadlines for environmental protection regulations as well as statements by the Environmental Protection Agency (EPA) that it has no plans for implementing more stringent requirements beyond those stipulated for air pollution control through 1982 and water pollution control through 1984.[1] Unless the actions taken by the current administration are reversed, environmental regulations should not be considered as serious constraints on the productive capacity of the domestic steel industry.

This chapter reviews the alternative steel policies that might be pursued and attempts to identify the implications of each policy for the interest groups involved. In the absence of change in the state of the regulatory environment as it existed in mid-1982, trade is the major area in which government policy instruments are of major importance to the steel industry. However, it is not certain that tax and environmental policies are in a state of equilibrium. Tax regulations that have a differential impact on the steel industry have been in flux for the past two years. Any additional changes to the Economic Recovery Tax Act (ERTA) of 1981 would have an important effect on the steel industry. It is also possible that more stringent environmental standards could be imposed under the present reauthorization proceedings on the Clean Air and Clean Water Acts, either through state or regional initiation, or by actions of federal agencies other than the EPA.[2] Therefore, the potential implications of changes in current tax and environmental policies on the domestic steel industry are also considered.

The major first-order effects of alternative policies are on the size and location of steel production capacity and the attendant costs. An important second-order effect is the consequence of changes in the size and location of capacity on employment, balance of payments deficit, and national security.

TRADE POLICY

There are a number of issues arising from the international trade in steel mill products that must be disentangled for a sensible discussion of policy:

- The current market for steel is so depressed that steel exporters sell their output at prices that do not cover full production costs.
- Some steel exporters cover their losses during this weak period through government assumption of liabilities or other forms of subsidy that inevitably increase output and reduce the probability of plant closures.
- In many countries, particularly the less developed nations, steel mills are financed in part or fully by government. In these economies exports may not have to meet any market test.

The first two issues listed above were discussed in Chapter 6. Government investment in the steel industries of developing countries is likely to be an increasing problem for U.S. producers.

As discussed in Chapter 4, it is likely that most of the investment in new (greenfield) integrated carbon steel plants will take place in developing countries in the next few decades. In virtually every emerging country in which steel investment is likely, government participation in or outright ownership of the mill is assured. U.S. trade policies will therefore have to be designed to take into account the increasing export pressures from these countries. While much of their output will be directed toward internal needs or those of their neighbors, they will likely try to ship their excess steel to U.S. markets. It is probable that imports from such countries will rise in relative importance from their current share of about 22 percent of the steel that is imported by U.S. consumers.

A commitment to free trade and faith in market mechanisms would imply that the federal government would, in the long term, assume a role limited to ensuring that the domestic industry has sufficient capacity to meet national security requirements. However, there are problems with this approach: There are no official or definitive estimates of that capacity requirement, and the virtually certain decline in the productive capability of the U.S. industry has political and regional economic ramifications that are unacceptable to a wide range of interest groups.

There are three main areas into which the various trade policy options may be placed: (1) current policies, (2) tariffs, and (3) reference (trigger) prices.

The positive aspects of all the trade policies discussed below are that they provide mechanisms for the reduction of imports to the U.S. markets (if that is deemed to be desirable) and that they do not require substantial government expenditures. On the negative side, adjustment assistance is supplied directly through transfers from the consumers to the producers of steel.[3]

These transfers are basically in the form of higher domestic prices of steel products and somewhat reduced domestic consumption. A number of analyses have been made of the effects of the two major U.S. interventions in the past 15 years (the VRAs and the TPM) on the domestic market; specifically the effects on the rate of inflation, transfers of income from consumers to domestic and foreign steel producers, and restricting domestic steel consumption.[4] Although there is general agreement among the analysts about the direction of the effects, there is disagreement over the magnitude, especially the inflationary impacts.[5]

For instance, Adams and Dirlam[6] estimated that in 1979 the TPM contributed to an increase in domestic steel prices on the order of 7.5 to 15.0 percent, which accounted for an overall increase in the domestic steel bill of about $3 to $6 billion. Crandall[7], on the other side, estimated that the TPM itself was responsible for only about a 1 percent increase in steel prices that year. There are similarly large variations in estimates of the effects of the VRAs on the price of both domestic and imported steel.

It has also been proposed that devices such as the VRAs and TPM[8] have served to validate wage and other cost pass-through efforts by the domestic industry. As shown in Table 3-9, the average hourly wage in the steel industry has increased from a level that was 26 percent greater than the average of all manufacturing in 1970 to a value 54 percent higher by 1981. Trozzo[9] estimated that if steel wages had grown at the same rate as the average of all durable wages from 1970 to 1980, wage rates would have been 22 percent less in 1980, reducing domestic steel industry costs by about $20 per ton. If all employee wages, salaries, and benefits had grown at the lower rate, the cost reduction would have been approximately $37 per ton of steel shipped in 1980.[10] The General Accounting Office[11] calculated that reducing the labor cost premium in the U.S. industry in 1980 to half of its value at that time would have lowered total production cost by about $4 billion, or $30 to $40 per ton.

Current Policies

In October 1982 U.S.-EEC negotiations culminated in an arrangement that forestalled once again the completed application of U.S. trade laws to imports of steel mill products. The eleventh-hour agreement resulted in the withdrawal of the countervailing duty and antidumping complaints that the U.S. industry had filed in January against 40 European companies regarding a wide range of hot- and cold-rolled products, plates, and structurals.

Under the agreement, notwithstanding previous unsatisfactory U.S. experience with quantitative limitations, the European steel producers limit their exports of carbon steel products to the United States. By means of an export licensing arrangement administered by the European Commission, the EEC exports over the period from November 1982 through December 1985 are restricted within ceilings set as maximum percentages of projected U.S. "apparent consumption." These percentages vary by product, ranging from 2.2 percent for tin plate to nearly 22 percent for sheet piling, with most hot- and cold-rolled product limits falling between 5 and 10 percent.[12]

Assessments of the efficacy of the arrangement, as well as its costs and benefits to the broader American economy, must await the accumulation of more experience under its implementation. However, prior to its negotiation and acceptance, the ongoing debate on quantitative restrictions raised a number of issues. First, although there has been some experience with the administration of quantity limitations, there was concern that their enforcement and efficacy in limiting imports into the United States would be more problematic under newly developing conditions, especially with the proliferation of steel producers and exporters in less developed countries.[13]

Second, quantity limitations, to the extent they are effective, have the distinct disadvantage that they eliminate entirely foreign price competition and weaken (1) the pressures on domestic producers to be efficient and (2) the constraints imports impose on domestic wage settlements.

Third, the quantity limitations can be expected to result in U.S. consumers of steel imports paying a higher price than they would have had to pay otherwise for their steel. In fact, the domestic consumers will probably have to pay a price for imports approaching the price of domestically produced steel mill products.

Fourth, as is the case with the licensing provisions under the arrangement, such quantity limitations generally cartelize the affected exporters through the official shipments allocation procedures administered by the overseas enforcement agency.[14]

However, quantitative limitations can be a most direct and verifiable means of reserving a specific market share for the domestic industry. Moreover, such restrictions are not susceptible to exchange rate fluctuations or impromptu changes in supply-demand balances.

In 1982 the U.S. steel industry also sought relief from Japanese imports, alleging that the Japanese industry had engaged in unfair trading practices. The unfair practices alleged were (1) the bilateral agreement between Japan and the EEC whereby the Japanese restrict exports of steel to Europe, thereby increasing the pressure to export to the United States, and (2) a consciously and persistently undervalued yen that permits the Japanese to maintain a competitive price advantage in the United States and world markets. The U.S. industry sought relief in the form of reduced steel shipments from Japan to the United States comparable to the reduction in Japanese exports to the EEC and an assessment of an import levy of 25 percent of the value of U.S. imports of Japanese steel to compensate for the undervaluation of the yen.[15] On February 25, 1983, the United States Trade Representative gave notice that he would not initiate the investigation and action requested by the U.S. industry.[16]

More recently, the International Trade Commission (ITC) recommended that quotas be placed on finished steel products from all sources (see Chapter 7), with allocations based on import shipments over the period 1979 to 1981. These quotas would have created an additional problem, namely, that developing countres could be the most seriously hurt since the level of their imports was small in the period prior to 1981 and relatively large since.

In the fall of 1984 the President rejected the ITC proposal in favor of pursuing voluntary quotas through bilateral negotiations with our trading partners. Such quotas, while potentially eliminating some problems of enforcement and allocation, would still be subject to the objections outlined above.

The Countervailing Duty-Antidumping Route

Prior to reaching the agreement with the EEC in October 1982, the United States had pressed a wide range of countervailing duty and antidumping cases against European exporters of steel mill products to this country. Under the preliminary determinations, exporters were required to post deposits against any subsidy or dumping margins that might ultimately be found. The final determination by the U.S. Department of Commerce in the subsidy investigation had found a number of significant instances of subsidized exports to the United States but also a substantial number of exporters who had received zero or negligible subsidies or subsidies of less than 5 percent. In the latter case, any countervailing duty levied on such imports would have little if any effect on their prices or quantities. The countervailing duty proceedings awaited only the final determination by the ITC on injury to a domestic industry to run their full course. The preliminary determinations on dumping also had found significant dumping margins in many instances. However, the traditional aversion to seeing such cases through to completion prevailed; there was concern that events could get out of control and a broader set of trade actions and reactions could be triggered by the final outcomes of the cases.

These cases involved 3.9 million tons of steel imports in 1981 valued at about $1.4 billion. This tonnage accounted for approximately 20 percent of total imports and about 4 percent of apparent consumption. As a result of the suits orders for most exports of steel products to the United States from most European producers have essentially dried up.

It is not clear what the consequences would have been if these cases had run their course. On the positive side, not short-circuiting the process for once by reaching a political settlement would have tested whether the threat of a trade war is real. There may be less to fear in such an approach than has been thought:

> If the United States obligates itself to submit to GATT review any positive findings as to subsidization, dumping, or injury made by the ITA or the ITC, the possibility of retaliation should be diminished. Moreover, letting the investigations proceed to their legal conclusions would have some salutary effects. For example, the domestic steel industry and everyone else would see spelled out the

> maximum extent of protection afforded by the U.S. fair trading laws. This determination might diminish the industry's ability to secure extraordinary relief from the Congress and the Administration. Also, some mix of positive dumping and subsidy findings by the United States could well give needed support to those E.C. [EEC] countries that continue to oppose steel industry subsidies within the E.C. [EEC] framework. Finally, antidumping and countervailing duties might well be earmarked for meaningful adjustment by the U.S. industry.[17]

The negative side of having remained on course is that there was no assurance that unfair-trade duties on European steel would prevent other countries such as Taiwan, Korea, Brazil (preliminary subsidy findings were about 8.6 percent, but only on plate), or even Japan from expanding their exports to backfill. Moreover, the task of determining the amount of subsidy for developing countries would be ambiguous. For instance, the emerging nations' steel facilities are clearly forced to accept a number of government-imposed inefficiencies. There is a question as to whether our import laws should require that these inefficiencies be added to the cost of production in determining fair market value. In addition, there would be difficulty in separating operating costs for current production from the costs of continuing construction of the plant's initial shakedown. Moreover, exchange rates and other prices may not reflect economic forces due to government intervention. The question is whether our trade policy administrators can adjust for these distortions.

The discussion above suggests that simplistic approaches to fair pricing of imports may be unworkable in the future. Determinations of subsidies, product costs, and fair market value will become increasingly difficult as governments assume more and more of the capital burden of the world steel industry. It is not clear that our countervailing and antidumping procedures can cope with these complexities. Finally, it should be noted that major trade suits have traditionally not been allowed to run their course through our administrative-legal procedures in some cases because of the time required and in others because of the potential for precipitating a trade war. Exporters and importers of steel must wait for nine months or more for the U.S. authorities (and the courts) to affirm the legality of their prices. Moreover, reports were circulating for some time that the Europeans were considering retaliating against U.S. chemical, textile, and agricultural products. Major dumping and countervailing duty suits have generally been settled in the past through a political adjudication among the complaining industry, the U.S. government, and its trading partners.

Tariffs

One alternative to quantity limitations or to letting the dumping and countervailing duty suits run their course is a tariff. The advantages of a tariff are simplicity of administration and enforcement, generation of revenues for the U.S. Department of the Treasury, and consistency with flexible and efficient pricing.[18] Disadvantages are possible inconsistencies with the GATT and the likelihood that our trading partners would impose similar duties on products that we export in abundance.

A variation on a straight tariff is one that is staged over time. It has been proposed that such a tariff could

> ...be devised initially to protect the domestic industry at its current size, but would fall over time so that the residual level of protection just assured domestic capacity sufficient for national security requirements. The solution essentially entails a combination of an escape clause proceeding and a Section 232 proceeding.
>
> Some flexibility in the administration of the tariff may be necessary. As steel industries develop in more countries overseas and new processes and raw material sources are introduced, the tariff's current level, rate of reduction, and final level may need to be modified.[19]

Trigger Price Mechanism

The relative merits of a revised trigger price mechanism are similar to those of a tariff, except that the revenues that accrue from such a system would go to foreign producers rather than the U.S. Department of the Treasury. Thus, even though it might be theoretically possible to devise a new trigger price system with similar features to the transitional tariff previously described, the unfavorable experience (of most of the interest groups involved) with the two previous attempts at reference prices mitigates against a renewed effort.

ENVIRONMENTAL POLICY

The economic effects of environmental controls (for air and water pollutants) on the U.S. steel industry was the subject of a recent report by Arthur D. Little, Inc. (ADL) for the American Iron and Steel Institute. Although it was pointed out that the accuracy of the estimates vary between ±15 percent and ±35 percent, it appears that environmental controls will not pose a major problem for the domestic industry if only current environmental requirements are enforced.

It was estimated that if the industry is allowed to meet current environmental requirements with the best available control technology equal to the best practicable control technology, the capital requirements necessary to meet environmental controls would force about one million annual tons of finished steel capacity from marginal facilities to be retired over the period 1981 to 1990. This represents approximately 1 percent of domestic capacity in 1981. If the industry were required to meet current environmental regulations strictly as written, the decline in production capacity from marginal facilities would be about two million annual tons over the same 10-year period. The ADL analysis indicated that if the steel industry did not have to meet environmental requirements over the 1981-1990 period, it would have the capital to increase its annual shipments from 92 million tons in 1981 to 105 million tons in 1990. Meeting current environmental requirements reduces the expansion to 103 million tons by 1990.

Only if the domestic steel industry were forced to meet projected future environmental requirements--defined to include such things as secondary air emission control on existing point sources, control of thermal pollution and storm runoff, and zero discharge of pollutants in water--would future capacity be significantly reduced. Under this scenario, the need to meet environmental regulations would reduce the projected future shipments by 9 million net tons to about 96 million tons in 1990.

TAX POLICY

In 1980 the Steel Tripartite Committee,[20] consisting of industry, labor, and government representatives, published a report analyzing the capital requirements and availability of a modernization program for the domestic steel industry.[21] The committee[22] estimated that during the period 1980 to 1984 the industry will require $4.7 billion (1980 dollars) to modernize its existing steelmaking capacity and $0.87 billion to meet environmental, safety, and health standards. Allowing for dividends based on 1979 levels of $450 million per year and an annual increase of $100 million in working capital, the industry's total annual capital uses over the 5-year period were estimated to average $6.1 billion. Assuming shipments of 85 million tons in 1980, and 1981 to 1984 shipments that result in an average 90 percent capacity utilization, the total capital sources of the industry were estimated to average between $4.1 and $4.4 billion per year. This implies an average annual shortfall of $1.7 to $2.0 billion (1980 dollars) during the period 1980 to 1984.

Because of the low profitability and therefore low tax liability of the steel industry, any tax proposal that merely reduced or eliminated the tax liability occurring under the 1980 system would have no significant impact on the projected 1980 to 1984 capital shortfall. Some form of faster capital recovery would, however, significantly benefit the industry after the five years of the modernization program. This would increase the long-term rate of return in the steel industry and presumably enhance the industry's ability to secure debt or equity financing.

Although the passage of the Economic Recovery Tax Act of 1981 (ERTA) changed the tax laws considerably, the basic conclusions of the Tripartite Committee regarding the effects of tax laws are still valid. Making optimistic assumptions about domestic steel shipments and using a financial analysis model of the steel industry developed for the Bureau of Mines by the Massachusetts Institute of Technology (MIT),[23] it was estimated that the tax laws as they existed after the passage of ERTA in 1981 would essentially eliminate the capital shortfall by 1985.

The estimates in the Tripartite Committee report as well as those made with the MIT model are subject to a number of qualifications, however. First, the magnitude of the capital shortfall is rather sensitive to the level of shipments and to the length of the period over which the shortfall is averaged. Second, both analyses dealt only with the capital required to modernize existing steelmaking capacity. It did not assess the appropriate size of the U.S. steel industry in the long run and the capacity expansion or reduction that may be required. The use of average data in the analyses also obscured the problems faced by individual companies. Profit levels, management strategies, financing capabilities, modernization requirements, and degrees of diversification vary considerably among companies.

A summary of ERTA is provided in Appendix A. The elements of this program essential to the domestic steel industry are the increased depreciation expenses and the new rules regarding leasing provisions (repealed in 1983) that were devised to make the business incentives in the tax act work.

Most industry observers felt that the creation of the new tax act--before the repeal of the safe-harbor leasing provision--essentially removed the obstacles that the old tax system placed on investment incentives for capital-intensive industries such as steel. As discussed in Chapter 4, it is not clear that any tax system will make new greenfield integrated plants an attractive investment in the United States, but at least the constraints that tax policy placed on modernization incentives have been removed.

Repeal of the safe-harbor leasing provisions of ERTA will have an adverse effect on the financial position of steel firms. Moreover, it should be pointed out that the transfer of tax incentives is not new. The entire financial leasing industry exists for little else.

The financial leasing industry behaves as a middleman that absorbs tax deductions and credits generated by business assets that cannot be used directly by the companies to which they belong. The leasing company purchases the assets, leases them to the firm that actually owns them, and takes the deductions and credits on its own tax return. It keeps part of the tax savings and returns the balance to the user by reducing the rentals that it charges under the lease.

One problem with the arrangement is that the U.S. Department of the Treasury does not get full value for its tax incentive dollar if a large percentage is transferred to a middleman. Moreover, in some cases, the potential transfer of incentives is so great (especially for risky investments) that the investment is never made. Other problems with the old regulations, according to a former Assistant Secretary for Tax Policy of the U.S. Department of the Treasury,[24] were that "they required the leasing company to invest unnecessarily large amounts and assume unnecessarily large risks, thus requiring that it siphon off more, and they insulated the leasing company from competition which would often cause it to siphon off less."

The 1981 tax act removed many of the regulations, with the result that "lessees that used to recoup perhaps 55 percent of their tax incentives from the lessor were beginning to recoup more than 90 percent."[25] However, with repeal of the safe-harbor leasing provision, the steel industry is again forced to deal with a middleman in leasing transactions.

TECHNOLOGY POLICY

The government has recently invested rather heavily in fairly basic research in materials in various university, government, and some industrial laboratories. This practice is desirable and might have some effect in the future on steel processes and products, as well as training needed personnel.

The government has also tended to encourage cooperative research between steel companies on large, costly projects by not refusing to permit such projects because of possible antitrust aspects. This policy should be continued.

In general, the industry prefers to fund its own research rather than accept government funding or sharing. Although exceptional cases should be weighed carefully, this policy seems appropriate.

ANTITRUST POLICY

Domestic steel firms are currently in the midst of a series of capacity contractions that should, in the long run, make the industry more competitive with international producers. Some of these contractions have taken the form of plant closures (e.g., the 6 million annual tons of capacity reduction announced by U.S. Steel in December 1983); others have been in the form of mergers and acquisitions, both with domestic and foreign firms. The major question facing the industry is whether these capacity contractions will take the form of outright plant closures or whether the industry will be allowed to restructure itself through mergers. In either case it is probable that further capacity and jobs will be lost. However, if steel industry firms are allowed to merge, some of the most efficient plants and facilities may be saved by combining the best parts of various operations.

Federal antitrust action to date has been ambiguous. For instance, the initial objections of the U.S. Department of Justice to the proposed LTV-Republic and U.S. Steel-National Steel mergers because of concentration of market power in the domestic market surprised many. This action was criticized by a number of steel market analysts as an unrealistic assessment of the nature of international competition.

SCENARIOS

As discussed in the beginning of this chapter, it is unclear what the capability of the domestic industry to produce finished steel will be 10 years from now. Moreover, there are a number of other factors that have an important causal effect on domestic steel production, consumption, and prices but cannot be forecast with confidence. To deal with this uncertainty, alternative scenarios have been developed that reflect the relative effects of critical indeterminate variables on the domestic industry and concerned parties.

There are a number of events that will have a significant impact on the future of the domestic steel industry and that are outside the control of the industry. Three of the most important of these exogenous events are economic activity, international exchange rates, and domestic trade law enforcement and legislation. Table 8-1 lists alternative outcomes for these exogenous events and the attendant consequences. The low and high economic growth events of Table 8-1 refer to the international economy and not just the United States. Economic growth, particularly in the construction and automotive industries (which account for roughly 40 percent of domestic steel consumption) is

TABLE 8-1 Consequences of Important Exogenous Events

Exogenous Events	Consequences
Low economic growth	1. Low demand for finished steel. 2. Higher unit production costs. 3. Decreased but continued investments by developing countries. 4. Increased pressure to export to the United States. 5. Low prices.
High economic growth	1. High demand. 2. Lower unit production costs. 3. Increased investment by developing countries. 4. Decreased pressure to export to the United States (but imports still high). 5. High prices.
Unfavorable exchange rates	1. U.S. costs relatively high.
Favorable exchange rates	1. U.S. costs relatively low.
Trade law enforcement or U.S. protectionism	1. Increased U.S. market share. 2. Higher domestic shipments. 3. Higher domestic prices.
Trade law enforcement or no U.S. protectionism	1. Decreased U.S. market share. 2. Lower domestic shipments. 3. U.S. price same as world price.

important because it is a principal determinant of steel consumption. Since carbon steel is essentially produced to meet demand in the short run, the level of steel consumption determines operating rates and therefore unit production costs.

Another consequence of slow growth rates in the world economy is that developing countries will not be able to expand their domestic steel industries as fast as they would like. Therefore, the low scenario for developing world steel capacity (discussed in Chapter 4) would be more likely to occur. However, another implication of slow international economic growth is that developing countries, because of slack domestic demand for steel products and subsidized production, would be more likely to seek to increase their exports to the most accessible and largest market in the world--the United States. Finally, slow growth will almost certainly result in continually depressed prices for steel products in the international market because of the overcapacity problem discussed in Chapter 4.

The effect of exchange rates on the relative costs of steel production in the United States and other countries is discussed in Chapter 3. It was shown that the strong dollar has considerably weakened the ability of domestic firms to compete with imported steel in the U.S. market, particularly in the coastal regions. The terms "unfavorable" and "favorable" exchange rates (of Table 8-1) refer to a relatively strong and weak dollar in the international market, respectively.

The objectives of more stringent enforcement of existing trade laws or some other form of protectionist measures for the domestic steel industry would obviously include increased domestic steel shipments. However, it is also likely that a concurrent effect would be relatively higher prices for domestic steel consumers than those paid by consumers in other countries.

There are eight possible combinations of the exogenous events shown in Table 8-1. Rather than discuss the implications of all eight possible outcomes, it is most instructive to examine the two extreme scenarios. Table 8-1 shows these in outline form.

The combination of low economic growth, unfavorable exchange rates (i.e., a relatively strong dollar), and lack of any import controls (i.e., no stringent trade law enforcement or protectionist measures) has been termed the "Apocalyptic Scenario" for obvious reasons. The outcome of such a combination of events, while resulting in low prices for domestic consumers at about international market levels, will almost surely be a substantial decline in domestic production capacity by 1990. Although the precise quantity is uncertain, a reduction of finished steel capacity to the level of approximately 70 million net tons would not be surprising.

The combination of high economic growth, favorable exchange rates, and some form of import controls is labeled the "Optimistic Scenario" because such an occurrence would result in a relatively strong domestic steel industry. However, steel consumers would probably be at a disadvantage in the world market because of relatively high domestic steel prices. The Optimistic Scenario could result in a domestic finished steel capacity of about 100 million net tons by 1990, approximately the same as that which existed in 1983, although the composition of the industry would be different. Electric furnace producers would have a large share of production, and integrated production capacity would shrink somewhat as high-cost facilities are closed even in the best of situations. However, even though capacity would not be increased (greenfield plants are not likely to be cost-effective under any realistic circumstances), the profitability of the remaining plants would be greatly improved.

One of the key issues is the employment consequences of possible policy actions. There will be a net reduction of steel industry jobs in the United States under any scenario because of productivity gains expected in the future. For instance, the production of carbon steel by the integrated route--which required approximately nine person-hours per ton of steel shipped in 1978--is projected to require only about eight person-hours per ton after

1985. In addition, the increasing share of electric furnace production will further increase the average productivity because minimills have averaged about three to four person-hours per ton of finished steel in the recent past. Therefore, although it is impossible to be precise, it is clear that there will be a net employment loss in the domestic steel industry even in the Optimistic Scenario.

In a recent Arthur D. Little study for the American Iron and Steel Institute, it was estimated that for each one million tons of steel shipments lost, approximately 4,500 workers would lose their jobs, and that there are (approximately) an equal number of workers associated with steel fabrication and other sections of the Standard Industrial Classification (SIC) iron and steel category. Assuming these estimates are approximately correct, the Apocalyptic Scenario would result in a direct loss of about 135,000 jobs by 1990 (capacity to produce finished steel would decrease from about 100 million to 70 million net tons). Indirect job losses or dislocations would amount to an additional 135,000.

CONCLUDING COMMENTS

Since there is no disagreement that the U.S. steel industry is in trouble, the key question is whether the government should take any steps to aid the revitalization of the industry. The answer to this complex question differs according to varying beliefs about the national security implications of the decline, the causes of the decline, and the effects of the decline on the economy. However, it is clear that none of the commonly recommended measures--including no action--will make all the parties involved better off; thus there appears to be an inherent conflict of interest. How this conflict is resolved will likely be determined by political compromise.

If the U.S. government does not provide support, the workers employed in the steel industry--at least in the older, less efficient plants--will suffer, along with the regions where such plants are located. It is possible (and perhaps more cost-effective, although a definitive analysis of the net economic costs of government policy alternatives has never been undertaken) to compensate these employees and regions by programs other than support for the steel industry, but so far there does not appear to be any comprehensive program to do so. The closing down of a big steel plant is likely to have a devastating effect on the economy and quality of life in the local community. Substantial declines will occur in the value of real estate around the plant, in the tax revenues to support schools, and in the economic activity of the local community. Who should be responsible for the loss of value of homes of the workers who must move into other occupations in other regions? Who should be responsible for maintaining the schools and for the health of the local economy? The shareholders of the steel companies may also suffer capital losses.

If the U.S. steel industry shrinks as a result of the lack of support from the government, some domestic consumers of steel may also suffer. These are the users to whom a reliable domestic supply is paramount, and the costs associated with the greater dependence on imports are related to the uncertainty of supply. For instance, during those periods in which the world industry is operating at a high rate of capacity utilization, U.S. consumers who are dependent on foreign sources of supply could expect not only higher prices but relatively longer order delays.

Therefore, it is likely that steel consumers would find it necessary to carry larger inventories and/or to utilize long-term contracts, with the associated costs. However, the infrequency of supply shortages and the cost of maintaining adequate capacity for such shortages may mitigate against direct government action.

Steel users in general are likely to lose if the government provides direct aid to the steel industry because most of the support measures--especially import restrictions--are likely to increase the price of both domestic and imported steel. There are also formidable practical and political difficulties associated with enforcing import restrictions, as we have discovered in recent years. Moreover our problems with imports are likely to be more severe in the future. Even if we are able to negotiate the narrow straits between successfully limiting European imports and precipitating a trade war, there is an entirely new series of exporters waiting on the horizon (e.g., Korea, Trinidad, and Brazil) as a result of the projected government involvement in the world industry. From the point of view of the economy as a whole, if the U.S. steel industry does not have a competitive advantage, supporting the industry may lead to a misallocation of real resources and a consequent reduction in welfare. On the other hand, if the industry's competitive position is weak not because of competitive disadvantage but because of other distortions, direct government action may be desirable. One such distortion may be excessive regulation.

The dominant issue is whether subsidization of foreign producers by their governments is such a distortion. On the one hand, if actions by foreign governments result in domestic consumers receiving lower-priced steel, this is almost like a free transfer of resources from abroad to domestic users. Unless there is some strong apprehension that foreign producers will collude and raise prices later on--which appears unlikely from an efficiency point of view--there is no reason to continue to allocate resources to the domestic industry. On the other hand, if subsidization by foreign governments results in increased imports to the U.S. market, as it almost surely will, this may be considered to be a policy of exporting unemployment and all the associated social costs.

Finally, another argument for supporting the U.S. steel industry is that national security will be compromised if the defense industries do not have access to domestically produced steel. It should be realized, of course, that protecting the steel industry as it exists now is the only one of the many possible ways of ensuring adequate steel supplies. One obvious alternative is to build up a strategic stockpile, which is the policy already followed for a number of critical materials. Also, there is no need to protect all of the steel industry; the capacity for current and future security requirements is all that needs protection. Thus, the older, less efficient plants could be allowed to close down without any effect on national security--in fact, some plants have already been closed down without any adverse effects. A shrunken (but more efficient) steel industry may be better able to fulfill security needs than an oversized, inefficient industry. It must be kept in mind that the civilian sector can always be squeezed to accommodate defense requirements in times of need.

NOTES

1. Arthur D. Little, Inc. (1981).
2. Ibid.
3. Trozzo (1982).
4. See Adams and Dirlam (1978); Crandall (1981); Jondrow (1978); Muelleter (1981); and Patrick and Sato (1981).
5. Trozzo (1982).
6. Adams and Dirlam (1978).
7. Crandall (1981).
8. See Mueller (1980b) and Trozzo (1982).
9. Trozzo (1982).
10. Ibid.
11. General Accounting Office (1981).
12. Arrangement, transmitted by letter to the Secretary of Commerce from Etienne Davignon, Vice-President of the Commission of the European Communities, October 21, 1982.
13. Mueller (1981).
14. Ibid.
15. American Iron and Steel Institute et al., Petition for Relief Under Section 301 of the Trade Act of 1974 from Certain Steel Products Imported from Japan, in the Office of the United States Trade Representative, December 16, 1982.

16. Office of the United States Trade Representative, American Iron and Steel Institute et al.: Notice of Decision Not to Initiate an Investigation Under Section 301 of the Trade Act of 1974.

17. Trozzo (1982).

18. Ibid.

19. Ibid.

20. Steel Tripartite Advisory Committee Report to the President (1980).

21. Elliot, Clark, and Tribendis (1978).

22. Report to the President (1980).

23. Elliot, Clark, and Tribendis (1978).

24. Hickman (1981).

25. Ibid.

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APPENDIX A
A Summary of the Economic Recovery Tax Act of 1981

The primary objective of the business section of the Economic Recovery Tax Act of 1981 (ERTA) was to provide incentive for capital formation. Therefore, the greatest benefits of the program accrue to capital-intensive industries, many of which have been underinvesting for years, at least partially because of tax bias against capital investment by such firms. In general, the program consists of revised depreciation rules that provide for faster write-off of asset costs and a simplified accounting system that eliminates the useful-life concept, salvage values, and differentiation between new and used property. In addition, tax credits have been revised and increased, and transfers of tax benefits are now allowed (i.e., selling benefits through new leasing provisions).

ACCELERATED CAPITAL RECOVERY SYSTEM

The revised depreciation rules are grouped under the title "Accelerated Cost Recovery System" (ACRS). The expected results of the ACRS are:

1. New assets may be depreciated faster (i.e., written off over a shorter period of time).
2. Increased depreciation expense will reduce taxable income, thus reducing tax liability and improving cash flow.
3. Companies can keep funds that would otherwise have been paid in taxes, presumably increasing the funds available for capital formation.

Prior to 1981 depreciation allowances were determined by an asset depreciation range (ADR) system. Under this system there were many asset classes, based on estimates of industry use. Compared with the ACRS there were relatively longer recovery

TABLE A-1 Comparison of Depreciation Expenses for Two Systems

Year	ACRS[a]	ADR[b]	Difference
1	$ 15,000	$ 8,333	$ 6,667
2	22,000	15,278	6,722
3	21,000	13,258	7,742
4	21,000	11,995	9,005
5	21,000	10,732	10,268
6	–	9,470	(9,470)
7	–	8,207	(8,207)
8	–	6,944	(6,944)
9	–	5,682	(5,682)
10	–	4,419	(4,419)
11	–	3,157	(3,157)
12	–	1,894	(1,894)
13	–	631	(631)
TOTAL	$100,000	$100,000	$ 0

[a] Accelerated Cost Recovery System.
[b] Asset Depreciation Range.

periods for most classes and often cause for disputes between the IRS and firms over class lines.

Under the ACRS there are now four classes of assets for depreciation purposes:

1. 3-year class
   a. automobiles, light trucks
   b. R&D equipment
2. 5-year class
   a. industrial machinery and equipment
   b. most personal property
3. 10-year class
   a. shorter-lived public utility property
   b. railroad tank cars
4. 15-year class
   a. longer-lived public utility property
   b. real estate

As an example of how the ACRS works in relation to the ADR system in the steel industry, consider that most steelmaking machinery and equipment have a 5-year depreciation life under ACRS, compared with a 12-year life under ADR. For a $100,000 investment in 1981, the amount that can be deducted from the tax bill as depreciation expense for the two systems over time is shown in Table A-1.

Two points should be made about the numbers presented above. First, the time value of money determines the benefit of the ACRS relative to the old system. The increased depreciation expense provides greater tax savings sooner, which are worth more in an inflationary economy. Second, in 1985 ACRS is scheduled to increase to a faster write-off (18, 33, 25, 16, 8 percent, respectively, for 5-year property), with further increases to follow.

APPENDIX B

Estimates of Requirements for Factors of Production and Costs of Some Important Unit Operations in the Steel Production Sequence

The assumptions regarding the factors of production and their associated costs for each of the important unit operations in the alternative steelmaking sequences discussed in the Future Costs section of Chapter 3 are made explicit in this appendix.

Table B-1 is a listing of the important assumptions concerning costs of factor inputs and capital costs. Although many of these assumptions are arbitrary, they can be easily changed to calculate the associated costs when making alternative assumptions.

Tables B-2 through B-15 illustrate the costs of producing steel by the most important unit operations.

In addition to the assumptions about factor inputs and prices specific to each unit operation, there are some general assumptions. First, it is assumed that the intermediate products of each unit operation were transferred to the next step of production at cost. This implies that profit is not taken by each operation, a reasonable assumption for large vertically integrated production facilities. If a producer is purchasing intermediates from an outside market, the market price of the intermediate will exceed its estimated cost of production. The model consistently underestimates the cost of producing steel in these situations.

Second, the price of factor inputs is assumed to be constant for all of the unit operations. For example, iron pellets for a blast furnace are taken to cost the same as pellets for direct reduction. Except for labor, this assumption is essentially valid. Labor wages vary with the unit operation and the skill required of the laborer.

Third, it is assumed that all factor inputs are purchased at 1983 market prices. This assumption denies the existence of purchasing contracts that are known to exist in the steel industry. Long-term contracts may effectively reduce the price of an input, especially in periods of strong inflation. For long-range forecasting, however, these contracts can be ignored since they will be periodically renegotiated.

Fourth, it is assumed that the by-products of each unit operation are valued at full market price. This assumption implies the existence of a market for all by-products. In integrated production facilities, the by-products of one operation may be inputs to the next operation. In large production facilities, it may be justifiable to recover and sell all by-products. However, in small nonintegrated facilities it is questionable whether by-product credits should be accounted.

TABLE B-1 Important Assumptions Regarding Factor Inputs and Prices Used in the Production-Cost Model

	Units	$/Unit
Energy		
Electricity	kilowatt hours	0.0525
Natural gas	thousand cubic feet	3.49
Fuel oil	gallons	0.82
Light oil	gallons	0.97
Tar and pitch	gallons	0.38
Coke oven gas	thousand cubic feet	1.95
Blast furnace gas	thousand cubic feet	0.25
Coking coal	short tons	55.00
Mixed fuels	million Btu	3.50
Steam	pounds	0.01
Low sulfur coal	short tons	48.34
Materials		
Iron ore	short tons	29.09
Limestone	short tons	13.00
Steel scrap	short tons	90.47
Oxygen	thousand cubic feet	2.00
Lime	pounds	55.00
Fluorspar	pounds	0.063
Refractories	pounds	0.10
Carbon electrode	pounds	1.00
Ferromanganese	pounds	0.20
Silico-manganese (SiMn)	pounds	0.21
Ferro-silicon (FeSi)	pounds	0.41
Coke breeze	short tons	68.00
Mill scale	short tons	23.00
Low-grade carbon electrode	pounds	0.15
Other		
Direct labor ($/man-hour)		25.00
Capital charges (percentage of initial investment)		15.0
Taxes (percentage of operating expenses)		1.2
Insurance (percentage of physical plant)		1.0
Maintenance (percentage of physical plant)		4.0
Years to recover investment		10

TABLE B-2 Cost of Pelletizing (basis: 1 short ton of pellets)

	Units	$/Unit	$/Short Ton
Process Materials			
Iron ore (short tons)	1.17	29.09	34.04
Limestone (short tons)	0.40	13.00	5.20
TOTAL			39.24
Energy			
Electricity (kilowatt hours)	95.00	0.0525	4.99
Low-sulfur coal (short tons)	0.01	48.34	0.48
TOTAL			5.47
Other			
Direct labor (man-hours)	0.205	25.00	5.13
Capital charges		15.0	10.67
Maintenance		4.0	2.14
Taxes		1.2	0.54
Insurance		1.0	0.54
TOTAL			19.01
Cost of Production ($/short ton)			63.72

NOTE: Initial investment of $18.75 million; production capacity of 350 kilotons/year.

TABLE B-3 Cost of Sintering (basis: 1 short ton of sinter)

	Units	$/Unit	$/Short Ton
Process Materials			
Iron ore (short tons)	1.08	29.09	31.36
Limestone (short tons)	0.090	13.00	1.17
Coke breeze (short tons)	0.056	68.00	3.81
Mill scale (short tons)	0.004	23.00	0.09
TOTAL			36.43
Energy			
Electricity (kilowatt hours)	30.00	0.053	1.58
Mixed fuels (millions of Btu)	1.682	3.50	5.89
TOTAL			7.46
Other			
Direct labor (man-hours)	0.277	25.00	6.93
Capital charges		15.0	9.96
Taxes		1.2	0.53
Insurance		1.0	0.50
Maintenance		4.0	2.00
TOTAL			19.91
Cost of Production ($/short ton)			63.81

NOTE: Initial investment of $15 million; production capacity of 300 kilotons/year.

TABLE B-4 Cost of Coking (basis: 1 short ton of coke)

	Units	$/Unit	$/Short Ton
Process Materials			
Coking coal (short tons)	1.45	55.00	79.75
TOTAL			79.75
Energy			
Electricity (kilowatt hours)	33.00	0.0525	1.73
Coke oven gas (1000's of cubic feet)	6.85	1.95	13.36
Blast furnace gas (1000's of cubic feet)	3.1	0.25	0.78
Steam (pounds)	667	0.01	6.67
TOTAL			22.54
Other			
Direct labor (man-hours)	0.463	25.00	11.58
Capital charges		15.0	55.10
Taxes		1.2	1.23
Insurance		1.0	2.77
Maintenance		4.0	11.06
TOTAL			81.73
Byproduct Credits			
Coke breeze (short tons)	0.063	68.00	(4.28)
Coke oven gas (1000's of cubic feet)	11.3	1.95	(22.04)
Tar and pitch (gallons)	10.364	0.38	(3.90)
Light oil (gallons)	3	0.97	(2.91)
TOTAL			(33.13)
Cost of Production ($/short ton)			150.89

NOTE: Initial investment of $860 million; production capacity of 3,110 kilotons/year.

TABLE B-5 Cost of Hot Metal Production in the Blast Furnace (basis: 1 short ton of pig iron)

	Units	$/Unit	$/Short Ton
Process Materials			
Iron ore (short tons)	0.17	29.09	4.80
Iron pellets (short tons)	0.99	63.72	63.27
Iron sinter (short tons)	0.41	63.81	26.03
Steel scrap (short tons)	0.05	90.47	4.52
Oxygen (1000's of cubic feet)	0.41	2.00	0.81
TOTAL			99.44
Energy			
Coke (short tons)	0.48	150.89	71.67
Electricity (kilowatt hours)	25.00	0.0525	1.31
Natural gas (1000's of cubic feet)	0.26	3.49	0.89
Fuel oil (gallons)	6.08	0.82	4.99
Tar and pitch (gallons)	0.91	0.38	0.34
Coke oven gas (1000's of cubic feet)	0.48	1.95	0.94
Blast furnace gas (1000's of cubic feet)	27.13	0.25	6.78
Steam (pounds)	3.89	0.01	0.04
TOTAL			86.96
Other			
Direct labor (man-hours)	0.277	25.00	6.93
Capital charges		15.0	21.93
Taxes		1.2	2.24
Insurance		1.0	1.10
Maintenance		4.0	4.40
TOTAL			36.59
Byproduct Credits			
Blast furnace gas (1000's of cubic feet)	50.76	0.25	(12.69)
Steel scrap (short tons)	0.016	90.47	(1.45)
Coke breeze (short tons)	0.022	68.00	(1.50)
TOTAL			(15.63)
Cost of Production ($/short ton)			207.36

NOTE: Initial investment of $685 million; production capacity of 6,225 kilotons/year.

TABLE B-6 Cost of Direct Reduction I (basis: 1 short ton of sponge iron; gas based)

	Units	$/Unit	$/Short Ton
Process Materials			
Iron ore (short tons)	0.00	29.09	0.00
Iron pellets (short tons)	1.42	63.72	90.48
TOTAL			90.48
Energy			
Electricity (kilowatt hours)	101.00	0.053	5.30
Natural gas (1000's of cubic feet)	19.70	3.49	68.75
Fuel oil (gallons)	6.08	0.82	4.99
TOTAL			79.04
Other			
Direct labor (man-hours)	0.175	25.00	4.38
Capital charges		15.0	23.03
Taxes		1.2	2.03
Insurance		1.0	1.16
Maintenance		4.0	4.62
TOTAL			35.22
Byproduct Credits			
Steel scrap (short tons)	0.016	90.47	(1.45)
TOTAL			(1.45)
Cost of Production ($/short ton)			203.30

NOTE: Initial investment of $89 million; production capacity of 770 kilotons/year.

TABLE B-7 Cost of Direct Reduction II (basis: 1 short ton of sponge iron, coal based)

	Units	$/Unit	$/Short Ton
Process Materials			
Iron ore (short tons)	0.00	29.09	0.00
Iron pellets (short tons)	1.43	63.72	91.12
TOTAL			91.12
Energy			
Electricity (kilowatt hours)	86.00	0.05	4.52
Fuel oil (gallons)	3.57	0.82	2.93
Coal (short tons)	0.55	48.34	26.59
TOTAL			34.03
Other			
Direct labor (man-hours)	0.2	25.00	5.00
Capital charges		15.0	31.13
Taxes		1.2	1.50
Insurance		1.0	1.56
Maintenance		4.0	6.25
TOTAL			45.45
Byproduct Credits			
Sulfur (pounds)	43	0.06	(2.58)
Steel scrap (short tons)	0.016	90.47	(1.45)
TOTAL			(4.03)
Cost of Production ($/short ton)			166.57

NOTE: Initial investment of $125 million; production capacity of 800 kilotons/year.

TABLE B-8 Cost of Steelmaking in the Basic Oxygen Furnace (basis: 1 short ton of hot steel)

	Units	$/Unit	$/Short Ton
Process Materials			
Pig iron, hot (short tons)	0.826	207.36	171.28
Iron sinter (short tons)	0.0040	63.81	0.26
Steel scrap (short tons)	0.32	90.47	28.95
Oxygen (1000's of cubic feet)	1.90	2.00	3.81
Lime (short tons)	0.084	55.00	4.62
Fluorspar (pounds)	10.00	0.06	0.63
Refractories (pounds)	26.00	0.10	2.60
Ferromanganese (pounds)	13.50	0.20	2.67
Silico-manganese (pounds)	1.50	0.21	0.32
Ferro-silicon (pounds)	2.50	0.41	1.03
TOTAL			216.15
Energy			
Electricity (kilowatt hours)	30	0.0525	1.58
TOTAL			1.58
Other			
Direct labor (man-hours)	0.407	25.00	10.18
Capital charges		15.0	10.96
Taxes		1.2	2.61
Insurance		1.0	0.55
Maintenance		4.0	2.20
TOTAL			26.50
Cost of Production ($/short ton)			244.22

NOTE: Initial investment of $11 million; production capacity of 200 kilotons/year.

TABLE B-9 Cost of Steelmaking in the Electric Arc Furnace I
(basis: 1 short ton of hot steel, scrap based)

	Units	$/Unit	$/Short Ton
Process Materials			
Steel scrap (short tons)	1.005	90.47	90.92
Limestone (short tons)	0.007	13.00	0.09
Pig iron (short tons)	0.028	207.36	5.81
Oxygen (1000's of cubic feet)	0.32	2.00	0.64
Lime (short tons)	0.03	55.00	1.65
Fluorspar (pounds)	12	0.06	0.75
Refractories (pounds)	26	0.10	2.60
Carbon electrode (pounds)	12.5	1.00	12.50
Ferromanganese (pounds)	11.00	0.20	2.17
Silico-manganese (pounds)	1.00	0.21	0.21
Ferro-silicon (pounds)	1.50	0.41	0.62
TOTAL			117.96
Energy			
Electricity (kilowatt hours)	500	0.0525	26.25
TOTAL			26.25
Other			
Direct labor (man-hours)	0.74	25.00	18.50
Capital charges		15.0	18.31
Taxes		1.2	1.73
Insurance		1.0	0.92
Maintenance		4.0	3.68
TOTAL			43.13
Cost of Production ($/short ton)			187.34

NOTE: Initial investment of $17 million; production capacity of 185 kilotons/year.

TABLE B-10 Cost of Steelmaking in the Electric Arc Furnace II
(basis: 1 short ton of hot steel, coal DRI)

	Units	$/Unit	$/Short Ton
Process Materials			
Steel scrap (short tons)	0.27	90.47	24.70
Coke (short tons)	0.006	150.89	0.91
Direct reduced iron (coal) (short tons)	0.85	166.57	141.58
Oxygen (1000's of cubic feet)	0.15	2.00	0.30
Lime (short tons)	0.13	55.00	6.88
Fluorspar (pounds)	8.00	0.06	0.50
Refractories (pounds)	26.00	0.10	2.60
Carbon electrode (pounds)	12.00	1.00	12.00
Ferromanganese (pounds)	11.00	0.20	2.17
Silico-manganese (pounds)	1.00	0.21	0.21
Ferro-silicon (pounds)	1.50	0.41	0.62
TOTAL			192.46
Energy			
Electricity (kilowatt hours)	650	0.0525	34.13
TOTAL			34.13
Other			
Direct labor (man-hours)	0.74	25.00	18.50
Capital charges		15.0	16.94
Taxes		1.2	2.72
Insurance		1.0	0.85
Maintenance		4.0	3.40
TOTAL			42.41
Cost of Production ($/short ton)			268.99

NOTE: Initial investment of $17 million; production capacity of 200 kilotons/year.

TABLE B-11 Cost of Steelmaking in the Electric Arc Furnace III (basis: 1 short ton of hot steel, gas DRI)

	Units	$/Unit	$/Short Ton
Process Materials			
Steel scrap (short tons)	0.27	90.47	24.70
Direct reduced iron (gas) (short tons)	0.85	203.30	172.80
Oxygen (1000's of cubic feet)	0.15	2.00	0.30
Lime (short tons)	0.13	55.00	6.88
Fluorspar (pounds)	8.00	0.06	0.50
Refractories (pounds)	26.00	0.10	2.60
Carbon electrode (pounds)	12.00	1.00	12.00
Ferromanganese (pounds)	11.00	0.20	2.17
Silico-manganese (pounds)	1.00	0.21	0.21
Ferro-silicon (pounds)	1.50	0.41	0.62
TOTAL			222.77
Energy			
Electricity (kilowatt hours)	650	0.0525	34.13
Coke (short tons)	0.006	150.89	0.91
TOTAL			35.03
Other			
Direct labor (man-hours)	0.74	25.00	18.50
Capital charges		15.0	16.94
Taxes		1.2	3.09
Insurance		1.0	0.85
Maintenance		4.0	3.40
TOTAL			42.78
Cost of Production ($/short ton)			300.58

NOTE: Initial investment of $17 million; production capacity of 200 kilotons/year.

TABLE B-12 Cost of Ingot Casting (basis: 1 short ton of ingots)

	Units	$/Unit	$/Short Ton
Process Materials			
Hot steel BF/BOF (short tons)	1.02	244.22	249.10
Energy			
Electricity (kilowatt hours)	30	0.0525	1.58
Mixed fuel (millions of Btu)	0.79	3.50	2.77
TOTAL			4.34
Other			
Direct labor (man-hours)	0.407	25.00	10.18
Capital charges		15.0	0.66
Taxes		1.2	3.04
Insurance		1.0	0.03
Maintenance		4.0	0.13
TOTAL			14.05
Byproduct Credits			
Steel scrap (short tons)	0.02	90.47	(1.81)
TOTAL			(1.81)
Cost of Production ($/short ton)			
Steel ingots BF/BOF (short tons)			265.68

NOTE: Initial investment of $1 million; production capacity of 300 kilotons/year.

TABLE B-13 Cost of Ingot Milling (basis: 1 short ton of bloom, slab, or billet)

	Units	$/Unit	$/Short Ton
Process Materials			
Steel ingots BF/BOF (short tons)	1.13	265.68	300.22
Energy			
Electricity (kilowatt hours)	30	0.0525	1.58
Mixed fuel (millions of Btu)	0.79	3.50	2.77
TOTAL			4.34
Others			
Direct labor (man-hours)	0.41	25.00	10.18
Capital charges		15.0	6.64
Taxes		1.2	3.65
Insurance		1.0	0.33
Maintenance		4.0	1.33
TOTAL			22.14
Byproduct Credits			
Steel scrap (short tons)	0.11	90.47	(9.95)
TOTAL			(9.95)
Cost of Production ($/short ton)			
Steel semi's BF/BOF (short tons)			316.75

NOTE Initial investment of $10 million; production capacity of 300 kilotons/year.

TABLE B-14 Cost of Continuous Casting (basis: 1 short ton of bloom, slab, or billet)

	Units	$/Unit	$/Short Ton
Process Materials			
Hot steel BF/BOF (short tons)	1.05	244.22	256.43
Hot steel EAF/DRI: gas (short tons)	1.05	300.58	315.61
Hot steel EAF/DRI: coal (short tons)	1.05	268.99	282.44
Hot steel EAF/scrap (short tons)	1.05	187.34	196.71
Energy			
Electricity (kilowatt hours)	30	0.0525	1.58
Mixed fuel (millions of Btu)	0.79	3.50	2.77
TOTAL			4.34
Other			
Direct labor (man-hours)	0.48	25.00	11.95
Capital charges		15.0	10.25
Taxes		1.2	3.21
Insurance		1.0	0.51
Maintenance		4.0	2.06
TOTAL			27.98
Byproduct Credits			
Steel scrap (short tons)	0.05	90.47	(4.52)
TOTAL			(4.52)
Cost of Production ($/short ton)			
Steel semi's BF/BOF			284.23
Steel semi's EAF/DRI: gas			343.41
Steel semi's EAF/DRI: coal			310.24
Steel semi's EAF/scrap			224.50

NOTE: Initial investment of $142 million; production capacity of 2,760 kilotons/year.

TABLE B-15 Cost of the Finishing Mills (basis: 1 short ton of steel products)

	Units	$/Unit	$/Short Ton
Process Materials			
Steel 1 semi's	1.10	316.75	348.42
Steel 2 semi's	1.10	284.23	312.65
Steel 3 semi's	1.10	343.41	377.75
Steel 3 semi's	1.10	310.24	341.26
Steel 5 semi's	1.10	224.50	246.96
Energy			
Electricity (kilowatt hours)	71	0.0525	3.73
Mixed fuel (millions of Btu)	0.79	3.50	2.77
TOTAL			6.49
Other			
Direct labor (man-hours)	1.83	25.00	45.75
Capital charges		15.0	28.46
Taxes		1.2	3.98
Insurance		1.0	1.43
Maintenance		4.0	5.71
TOTAL			85.34
Byproduct Credits			
Steel scrap (short tons)	0.09	90.47	(8.14)
TOTAL			(8.14)

NOTE: Initial investment of $100 million; production capacity of 700 kilotons/year.

TABLE B-16 Total Cost of Producing Carbon Steel Sheet by the Fire Process Routes

	$/Short Ton
Cost of Production ($/short ton)	
Sheet steel 1	432.11
Sheet steel 2	396.34
Sheet steel 3	461.44
Sheet steel 4	424.95
Sheet steel 5	330.65

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